



INSTRUCTIONS

DIESEL ENGINE

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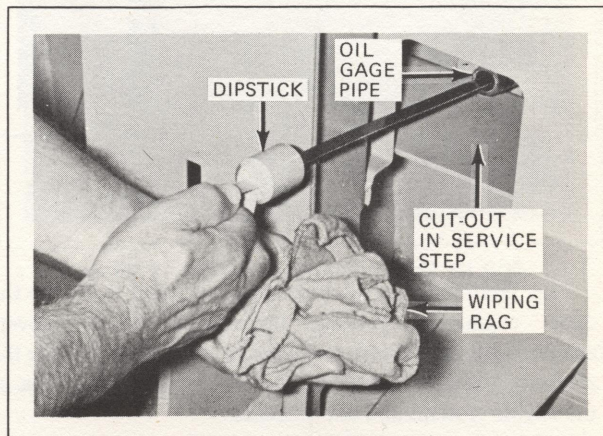


FIG. IX-1. CHECKING LUBE-OIL LEVEL.

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These instructions do not purport to cover all details or variations in equipment nor to provide for every possible contingency to be met in connection with installation, operation or maintenance. Should further information be desired or should particular problems arise which are not covered sufficiently for the purchaser's purposes, the matter should be referred to the General Electric Company.

Verify numbers for parts, tools, or material by using the Renewal Parts or Tool Catalogs, or contact your General Electric representative for assistance. Do not order from this publication.

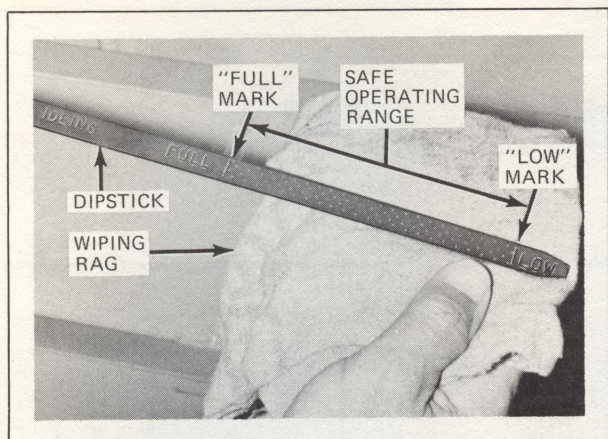


FIG. IX-2. CRANKCASE DIPSTICK.

INTRODUCTION

This section covers the procedures required to service the diesel engine at periodic inspections. It also covers replacement procedures that may be required following the performance of the necessary checks and adjustments of the engine systems and components.

CHECKS

CRANKCASE OIL LEVEL

With the engine running at IDLE speed, remove the dipstick, Fig. IX-1, and wipe it clean. Install the dipstick to its full depth and quickly remove and read the indication which should be between the FULL and LOW marks on the dipstick, Fig. IX-2.

If oil level is low, add oil at fill pipe, Fig. IX-3, until level is at, or near, the FULL mark on the dipstick. Replace and secure the fill cap.

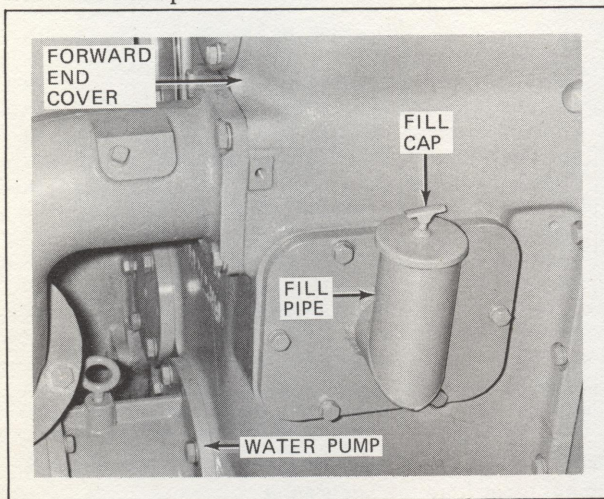


FIG. IX-3. LUBE-OIL FILL.

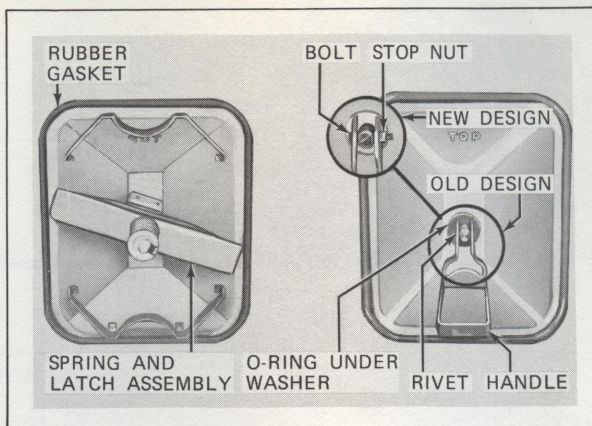


FIG. IX-4. CRANKCASE INSPECTION COVER.

CAUTION: Do not fill above the FULL mark. This may cause a false Crankcase Overpressure (COP) switch operation.

CRANKCASE INSPECTION COVERS

After engine has run for a long time period and before any crankcase covers, Fig. IX-4, have been removed, check both sides of the engine main frame. At each cover location, check for lube-oil leakage in the following areas:

1. Past the gasket which seals the cover to the face of the main frame
2. Around the latch shaft where it passes outward through the cover.

Leakage at either area should be corrected immediately by renewing defective gaskets and O-rings.

CRANKCASE STRAINER

With engine shut down, remove appropriate crankcase inspection covers. Work thru convenient openings and remove the strainer cover, Fig. IX-5 and Fig. IX-6, which is identical to the covers on the sides of the main frame. Lift out the strainer basket and examine the inside of the basket. Analyze any debris collected in the basket.

Clean the basket before reinstalling. Check the cover gasket and O-ring around the latch shaft; if not in good condition, renew.

NOTE: Leakage at either the gasket or the O-ring together with a low lube-oil level will cause a low-oil shutdown.

FIG. IX-2, E-25552

FIG. IX-3, E-25553

FIG. IX-4, E-9977B

FIG. IX-5, E-18304

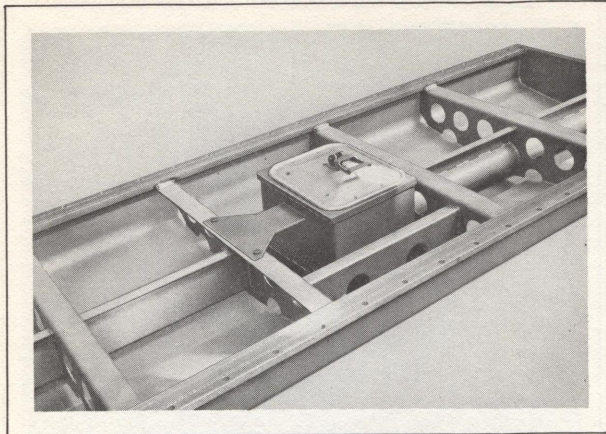


FIG. IX-5. ENGINE OIL PAN WITH STRAINER COMPLETELY ASSEMBLED.

FIG. IX-6, E-18305

ENGINE GOVERNOR OIL LEVEL

With the engine running at IDLE speed, check the oil level in the sight glass, Fig. IX-7. Correct level is at, or slightly below, the line in the sight glass; if level is above the line, the excess oil will spill out thru the vent in the top of the sight glass when the engine is shut down.

If oil level is low, add clean SAE 10W-30 governor oil thru the fill cap on the top of the governor cover. Fill with the engine running at IDLE speed until oil level in sight glass is at the line in the sight glass.

COOLING WATER LEVEL

Check the cooling water level after the engine has been idling for at least ten minutes. This will assure all water has drained from the radiator back to the storage tank. Correct water level is between the FULL AT IDLE and LOW AT IDLE marks in the sight glass, Figs. IX-8 and IX-9.

FIG. IX-7, E-25085

FIG. IX-8, E-25554

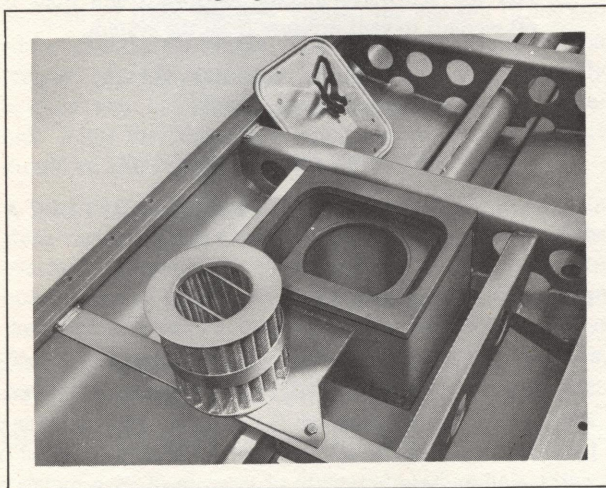


FIG. IX-6. STRAINER WITH BASKET REMOVED.

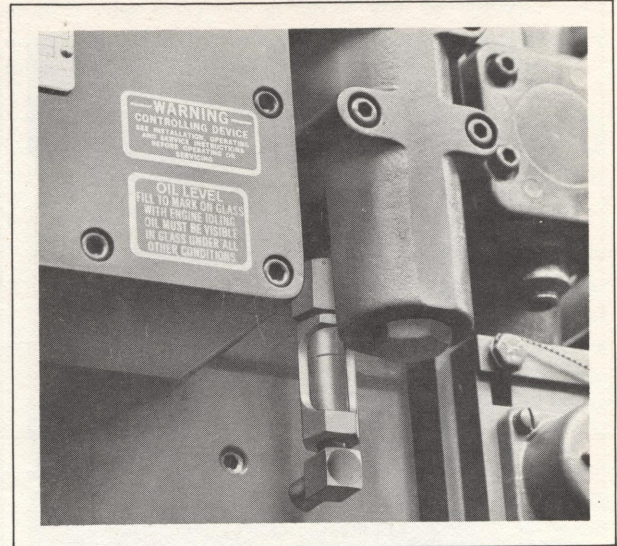


FIG. IX-7. GOVERNOR-OIL SIGHT GLASS.

If cooling water is below the LOW AT IDLE mark, add water to the correct level by one of the following methods:

Thru the Water Fill Pipe, Fig. IX-9 –

1. Attach the hose on the end of the water supply to the fill pipe connection
2. Turn on the water supply
3. Pull down the spring-loaded handle on the water fill valve
4. Hold handle down until water level is at the FULL AT IDLE mark
5. Slowly raise the spring-loaded handle to its normal vertical position

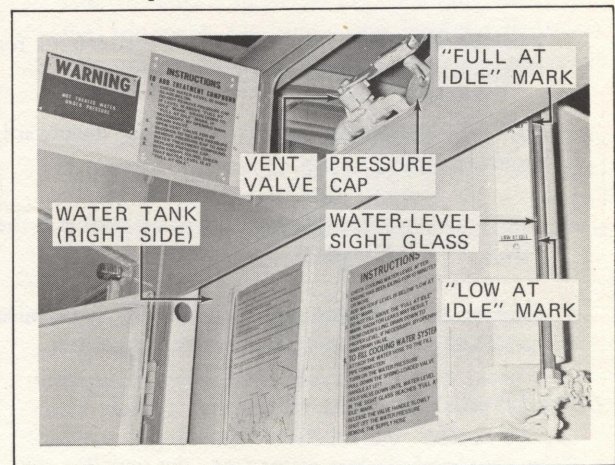


FIG. IX-8. COOLING WATER-LEVEL GAGE.

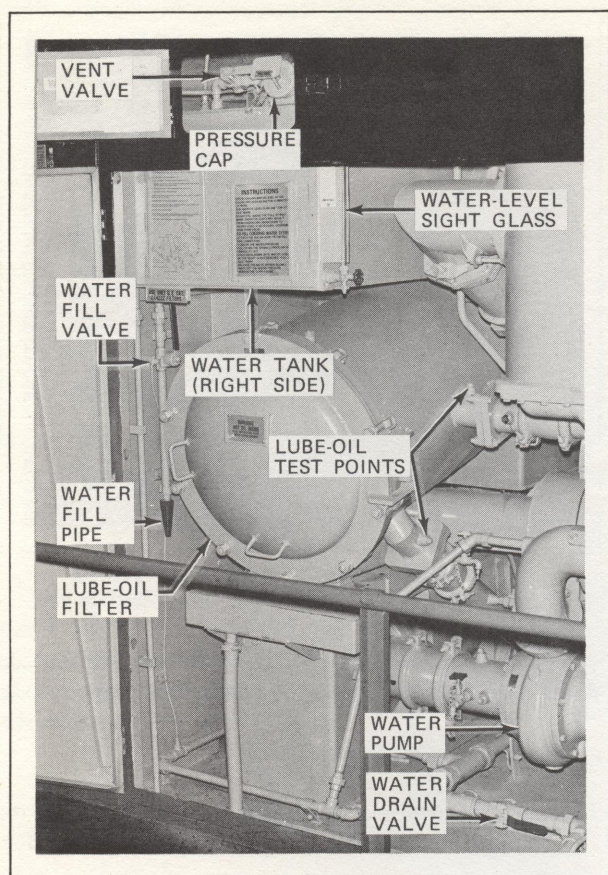


FIG. IX-9. COOLING WATER FILLS AND DRAIN.

6. Shut off the water supply
7. Remove the water supply hose from the connection.

Thru the Fill Pipe Covered by the Pressure Cap, Figs. IX-8 and IX-9 –

1. Pull the vent-valve handle downward and hold for 60 seconds to vent pressure from the system
2. With the vent-valve handle still held downward, remove the pressure cap
3. Add water thru the fill pipe until water level is at the FULL AT IDLE mark
4. Replace the pressure cap and allow the vent-valve handle to return to its normal horizontal position.

COOLING WATER ANALYSIS

Take sample of cooling water from the sampling valve, Fig. IX-10. Have sample analyzed by laboratory and take

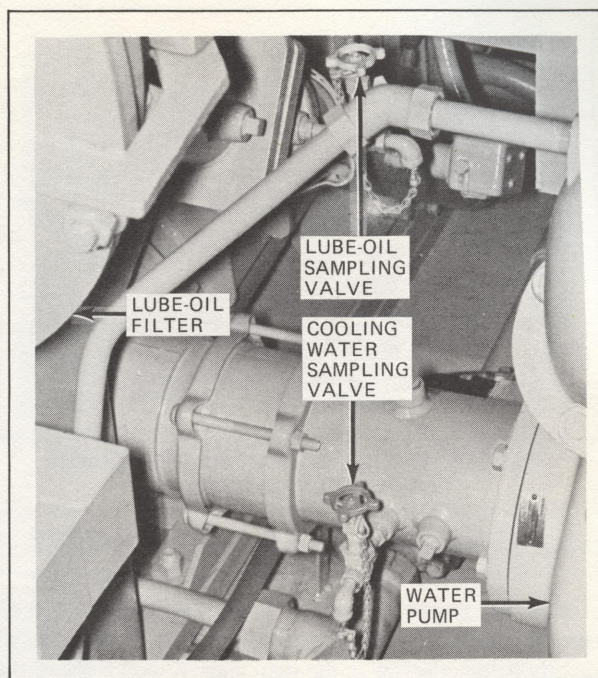


FIG. IX-10. SAMPLING VALVES.

appropriate action based on the analysis. That is, change cooling water, add treatment, find and correct exhaust leak, etc. If treatment compound is required, add it thru the fill pipe covered by the pressure cap, Figs. IX-8 and IX-9, in the following manner:

1. Check the water level in the sight glass with the engine idling.
2. Do not remove the pressure cap if level is above FULL AT IDLE mark. Drain down till level is at FULL AT IDLE mark.
3. Pull the vent-valve handle downward and hold for 60 seconds to vent pressure from the system.
4. Remove the pressure cap and add the required amount of treatment compound.
5. Replace the pressure cap.
6. With engine idling, check water level is at FULL AT IDLE mark.

LUBE-OIL ANALYSIS

Take sample of lube oil from the sampling valve, Fig. IX-10. Have sample analyzed by laboratory and take appropriate action based on the analysis. That is, change lube oil, find and correct cause of dilution by fuel oil or water, find and correct cause of increase of such metals as copper, iron, chromium, aluminum, etc.

FIG. IX-9, E-25555

FIG. IX-10, E-25556

FIG. IX-11, E-25557

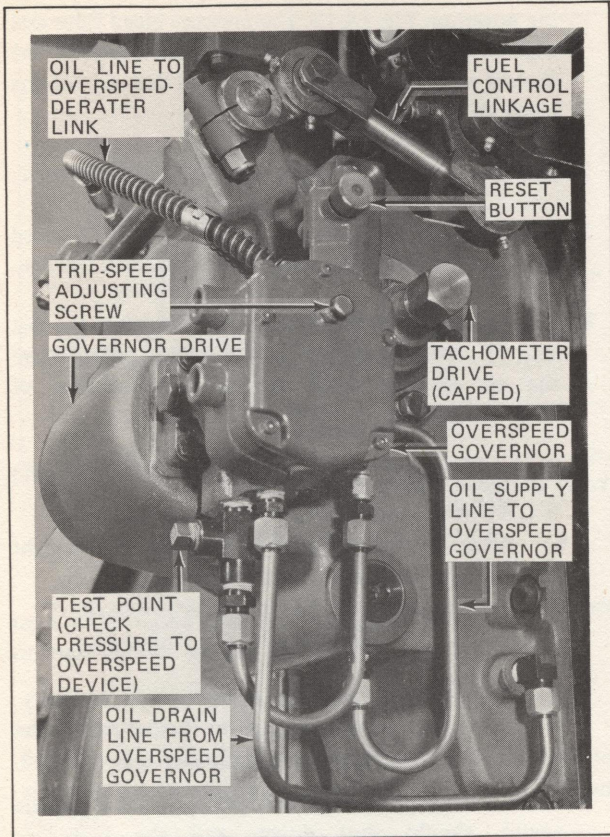


FIG. IX-11. TYPICAL OVERSPEED GOVERNOR ARRANGEMENT.

OVERSPEED GOVERNOR OUTPUT OIL PRESSURE

With the engine shut down, remove the pipe plug and install a 0-300 psi pressure gage in the test point below the overspeed governor, Fig. IX-11. While cranking the engine, crack a fitting in the oil line to the overspeed-derater link to bleed all air from this line. Tighten the cracked fitting and while cranking the engine, note the output oil pressure on the test gage. A pressure of 95 to 175 psi should quickly develop and completely compress the overspeed-derater link. After the engine is running, the output oil pressure should be 180-220 psi.

Low output oil pressure can be caused by a dirty or stuck regulating valve located in the oil inlet portion of the overspeed governor or by excessively worn gears in the pump portion of the overspeed governor. Remove, clean the regulating valve and reinstall it in the governor. If this does not correct the low output oil pressure condition, replace the overspeed governor with a new or rebuilt unit.

OVERSPEED GOVERNOR TRIP SPEED

The trip speed is best checked with the overspeed governor set up on a governor test stand. When this is not

possible, the overspeed governor can be checked when mounted on the diesel engine. The trip speed is checked in the locomotive in the following manner:

1. Install a direct-reading, accurately-calibrated tachometer. Attach it to the standard SAE tachometer drive located on the forward side of the governor drive, Fig. IX-11.
2. With engine running at Notch 8, no load speed, apply a pry bar to the overspeed link to override the governor and increase engine speed. Pivot the pry bar on the head of the clamp bolt which secures the fuel-linkage lever attached to the bottom of the link, and allow the pry bar to apply an upward force to the bottom of the oil inlet boss. **DO NOT APPLY FORCE AGAINST OIL FITTING OR HOSE.** A downward pressure on the outer end of the pry bar will thus raise the overspeed link and the governor power piston, and will cause the fuel pump racks to extend and increase engine speed. At the same time, the overspeed link is free to extend itself when the overspeed governor trips.
3. Slowly and cautiously, raise the engine speed to 1155 ± 10 crankshaft rpm (1738 ± 15 tachometer drive rpm).
4. If the overspeed governor does not trip at speeds specified in Step 3:
 - a. Remove the pry bar.
 - b. With the engine still in Notch 8, no load speed, back out (turn counterclockwise) the overspeed governor trip-speed adjusting screw until the governor trips.
5. Return Throttle handle to IDLE and restart the engine.
6. Apply the pry bar, as outlined in Step 2, and slowly raise the engine speed. At the same time slowly turn the trip-speed adjusting screw inward (clockwise). Alternate turning the adjusting screw and increasing the speed until correct trip speed is achieved.

By keeping a close observation and promptly depressing (at about IDLE speed) the overspeed governor reset button after tripping, the engine will ordinarily recover and continue operating without the need for additional cranking.

CAUTION: While checking the overspeed governor trip speed, never exceed 1200 crankshaft rpm (1783 tachometer drive rpm). Exceeding this speed may cause serious damage to the engine and to the auxiliary equipment mechanically driven by the engine.

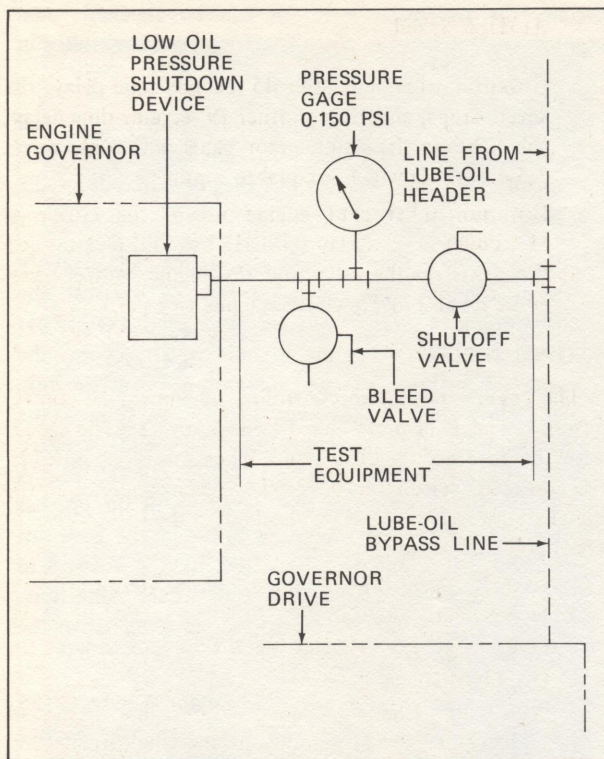


FIG. IX-12. SCHEMATIC DIAGRAM SHOWING TEST EQUIPMENT FOR CHECKING LOW OIL PRESSURE SHUTDOWN DEVICE.

OVERSPEED-DERATER LINK

Check to ensure that air and oil supply connections are tight, and hoses are free of leaks.

Check to ensure that link moves freely from its fully-opened to its fully-closed position, and from its fully-closed to its fully-opened position. This is accomplished by starting and running the engine, and then shutting the engine down. While running the engine note that link is fully closed by observing the top edge of the indicator aligned with the lower groove on the outer casing, Fig. IX-34.

ENGINE GOVERNOR LUBE-OIL TRIP PRESSURE

While the governor is best checked on a governor test stand, it can be checked on the locomotive in the following manner:

NOTE: The engine speed may hunt during the following test. Hunting is not a reason for disqualifying an engine governor.

1. Install a test shutoff valve, a 0-150 psi pressure gage and a pressure bleed valve in the engine oil supply line where it connects to the low-oil pressure device on

the governor, Fig. IX-12. The pressure bleed valve and gage must be connected in the line between the shutoff valve and the governor with one side of the bleed valve open to atmosphere.

2. Open the test shutoff valve and close the bleed valve.
3. Start the engine and allow it to operate at IDLE speed until normal operating temperature has been reached.
4. Run the engine at Notch 8 speed. Then close the test shutoff valve and slowly open the bleed valve. When the oil pressure drops to the trip pressure of 45.5-46.5 psi:
 - a. The Engine Governor Relay (EGR) should pick-up
 - b. After 19 seconds the LOW OIL PRESSURE light on the annunciator panel will come on.

When the oil pressure is reduced about 2 to 3 psi below the trip setting, the engine should start to reduce speed.

When the bleed valve is opened to further reduce the oil pressure, the engine should further reduce speed.

When the oil pressure is reduced to about 4 psi, the engine should shut down, and the Governor Shutdown Hold Relay (GSDHR) should pick-up. This will cause a light on the relay and a light on the engine control panel to come on.

5. Close the bleed valve and open the shutoff valve.
6. After three minutes, reset the Governor Shutdown Hold Relay (GSDHR).

NOTE: The lights on the engine control panel and the relay should go off. If they do not go off, it indicates that the governor has not yet reset. Wait four minutes and again reset the governor shutdown hold relay. If lights do not go off, and stay off, change out the governor.

7. Operate the reset switch on the annunciator panel to cause the annunciator panel light to go off.
8. Restart the engine and operate at IDLE speed. Then close the test shutoff valve and slowly open the bleed valve. When the trip pressure of 7-14 psi is reached, and after 45 seconds time delay, the engine speed should decrease. When the pressure is further reduced to about 4 psi, the engine should shut down and the lights on the engine control panel and the Governor Shutdown Hold Relay (GSDHR) should come on.

FIG. IX-13, E-21436

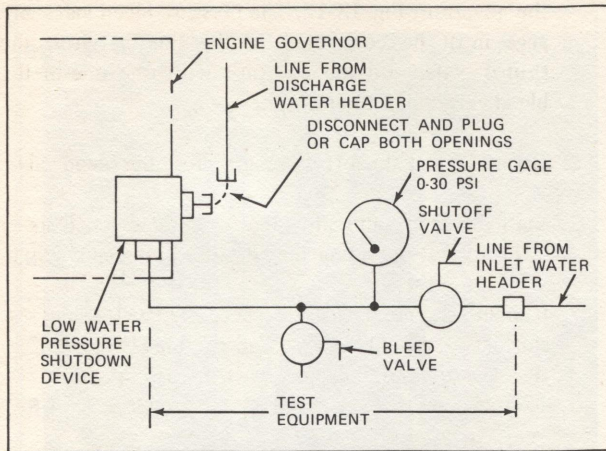


FIG. IX-13. SCHEMATIC DIAGRAM SHOWING TEST EQUIPMENT FOR CHECKING LOW WATER PRESSURE SHUTDOWN DEVICE.

9. Repeat Steps 5, 6 and 7, remove the test equipment and restore the original piping.

ENGINE GOVERNOR WATER TRIP PRESSURE

While the governor is best checked on a governor test stand, it can be checked on the locomotive in the following manner:

NOTE: The engine speed may hunt during the following test. Hunting is not a reason for disqualifying an engine governor.

1. Install a test shutoff valve, a 0-30 psi pressure gage (or a mercury manometer) and a pressure bleed valve in the engine water pressure line where it connects to the low water pressure device on the governor, Fig. IX-13. Also disconnect the line from the water discharge header to the low-water pressure device on the governor, at the device. Plug or cap each side of this break.
2. Follow the same procedure outlined in the Engine Governor Lube-Oil Trip Pressure section except use the following values of water pressure:

At Notch 8 Speed –

Governor trips, Engine Governor Relay (EGR) picks-up, speed starts to drop and, after 19 seconds, the LOW WATER PRESSURE light on the annunciator panel will come on at 22-29 in. of mercury (in. Hg) which is equal to 11-15 psi.

Governor must shut engine down, the Governor Shutdown Hold Relay (GSDHR) should pick-up, the lights on the relay and the engine control panel come on at 2 in. Hg which is equal to 1 psi.

At IDLE Speed –

Governor trips and, after 45 seconds time delay, the speed drops, and after another 19 seconds time delay, the light on the annunciator panel will come on at 3.5-4.5 in. Hg which is equal to 2 psi.

Governor must shut engine down, the Governor Shutdown Hold Relay (GSDHR) should pick-up and the lights on the relay and the engine control panel come on at 2 in. Hg which is equal to 1 psi.

ENGINE SPEEDS

The engine speeds are controlled by the engine control governor and it is preferable to check and set the speeds with the governor on a test stand. When this is not possible, the control governor can be checked when mounted on the diesel engine. The speeds are checked, in the locomotive, in the following manner:

1. Install a direct-reading, accurately-calibrated tachometer. Attach it to the standard SAE tachometer drive located on the forward side of the governor drive, Fig. IX-11.
2. With the engine running at normal operating temperature and at no load, advance the throttle thru all notches. Dwell in each notch long enough for the engine speed to stabilize, then read the speed on the tachometer.

NOTE: If locomotive has a standard speed schedule, refer to Table IX-I for correct values for engine crankshaft speeds. This table also gives equivalent tachometer drive speeds for each throttle notch. Many locomotives have a special speed schedule which is identified by comparing the values given in Table IX-I with those found on the locomotive electrical schematic diagram. When a special speed schedule is used, use the speed values given on the schematic diagram and not those given in Table IX-I. Be certain that the schematic diagram applies to the locomotive being checked.

TABLE IX-I
STANDARD SPEED SCHEDULE

Throttle Position	Engine Crankshaft rpm	Tachometer Drive rpm
Idle	444-453	660-673
1	444-453	660-673
2	519-549	771-816
3	606-636	900-945
4	702-710	1043-1055
5	778-808	1156-1201
6	874-882	1299-1310
7	960-968	1426-1438
8	1045-1055	1553-1568

DIFFERENTIAL PRESSURE — ACROSS LUBE-OIL FILTER

With the engine shut down, install 0-150 psi pressure gages in the test points (Fig. X-2 and Fig. IX-9) in the pipes into, and out of, the filter.

With the engine running in Notch 8 speed and the lube oil at normal operating temperature of 200-210 F, read pressures on both gages. Subtract the lower pressure from the higher pressure to get the differential pressure, or drop in pressure, across the filter. With new filter elements in the filter, the differential pressure should be 5-9 psi; filter elements should be changed when the differential pressure exceeds 25 psi.

DIFFERENTIAL PRESSURE — ACROSS LUBE-OIL COOLER

With engine shut down, install 0-150 psi pressure gages in the test points (Fig. X-2) in the pipes into, and out of, the oil cooler.

With the engine running in Notch 8 speed and the lube oil at normal operating temperature of 200-210 F, read pressures on both gages. Subtract the lower pressure from the higher pressure to get the differential pressure, or drop in pressure, across the cooler. With a clean cooler, the differential pressure should be 15-21 psi.

While an increase in the differential pressure will be indicative of dirt (sludge) accumulating in the cooler, the preferred method of determining when a cooler should be cleaned is to measure the performance of the cooler. See Determining Lube-Oil Cooler Condition section.

DETERMINING LUBE-OIL COOLER CONDITION

To determine if the lube-oil cooler requires cleaning, the maximum stable temperature of the lube oil leaving the engine and the cooling water entering the cooler must be accurately measured and plotted on the graph, Fig. IX-14. Measurements plotted should fall between the two curves; clean the cooler if the plotted measurements fall above the upper, condemning limit curve.

To obtain maximum stable temperatures in the systems, during the cooler test, the engine must be operated for a sufficient length of time at its full horsepower rating. At no time during the test should the temperature of the lube oil leaving the engine be permitted to exceed 220 F.

To perform the test, install two accurate 250 F temperature gages, one at each of the following points:

1. In the lube-oil pump discharge pipe (Fig. X-2).

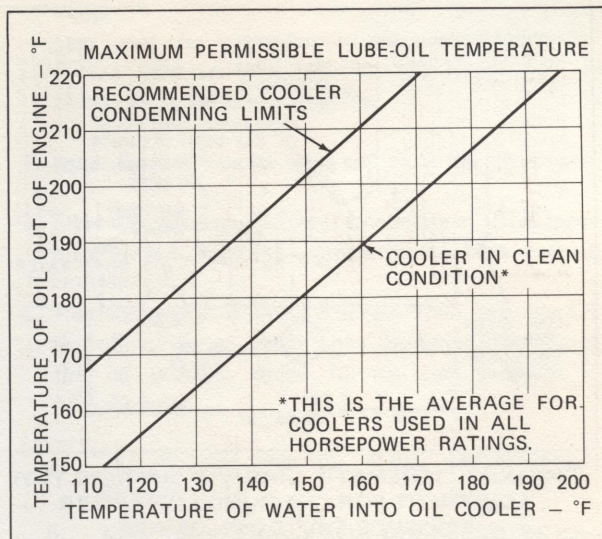


FIG. IX-14. LUBE-OIL COOLER
PERFORMANCE GRAPH.

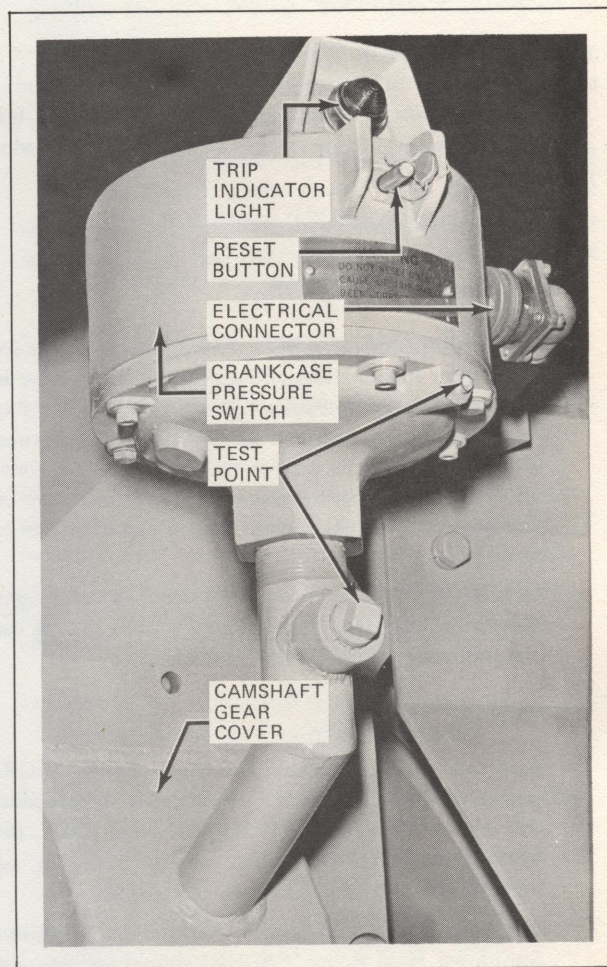


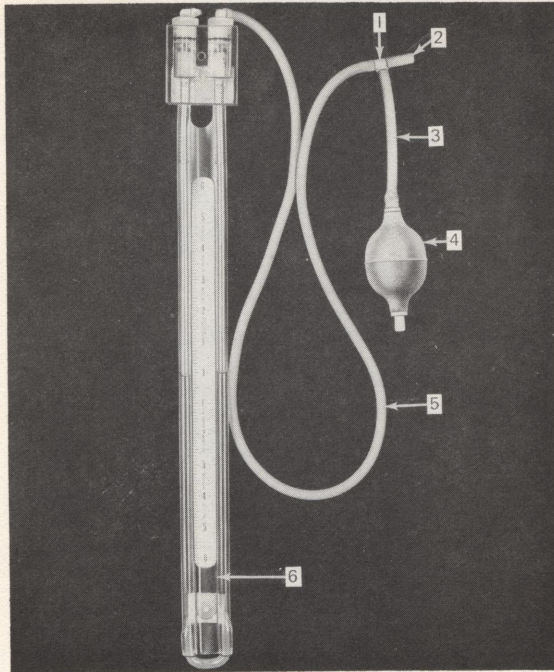
FIG. IX-15. ENGINE CRANKCASE PRESSURE SWITCH
SHOWING CRANKCASE PRESSURE TEST POINTS.

FIG. IX-14, E-13524A

FIG. IX-15, E-25558

FIG. IX-16, E-14841

FIG. IX-17, E-21627



REF.	DESCRIPTION
1	PLASTIC TEE
2	RUBBER TUBING, 3/16 IN. I.D., 1/2 IN. LONG
3	RUBBER TUBING, 3/16 IN. I.D., 5 IN. LONG
4	RUBBER BULB (DOUBLE ACTING)
5	RUBBER TUBING, 3/16 IN. I.D., 18 IN. LONG
6	MANOMETER 12 IN.

FIG. IX-16. SLACK TUBE MANOMETER TEST KIT, PART 147X1475.

2. In the lower right corner of the left-side water tank where the standard temperature gage is normally installed (Fig. X-4).

CRANKCASE PRESSURE

Connect one side of a slack tube manometer, Part 147X1475, to the crankcase. Two convenient connection points are shown in Fig. IX-15. Engines will have one connection point or the other while some will have both points.

With the engine running, measure the difference in water levels in the two vertical legs of the manometer, Fig. IX-16. This difference in levels, expressed as "inches of water" or as "in. H₂O" is the crankcase pressure. Normal crankcase pressure is slightly negative in. H₂O to very slightly positive in. H₂O.

NOTE: When the crankcase pressure exceeds plus 1.9 to 2.1 in. H₂O, the Crankcase Overpressure switch (COP) should trip and shut down the engine.

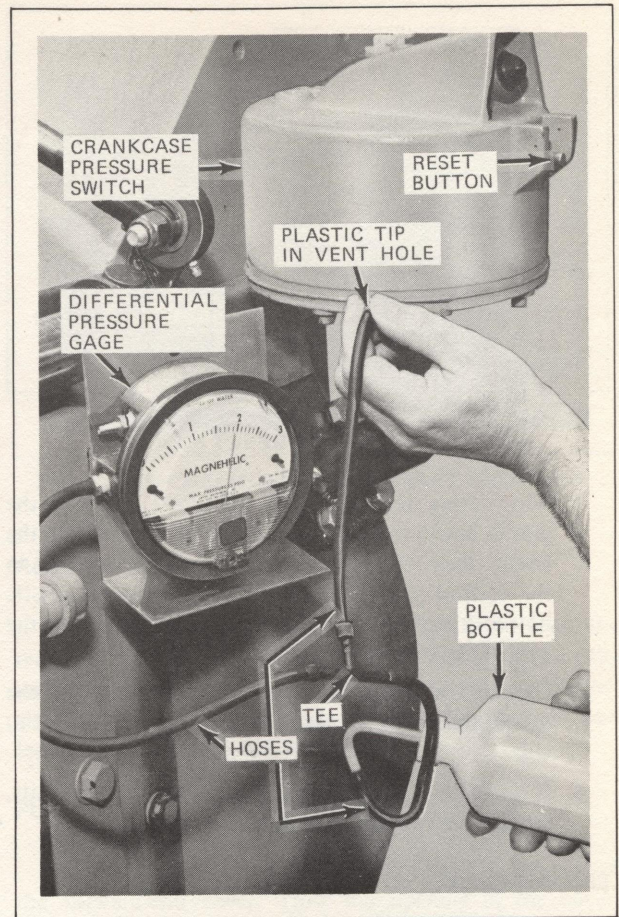


FIG. IX-17. CHECKING CRANKCASE PRESSURE SWITCH WITH TEST KIT, PART 147X1995.

CRANKCASE PRESSURE SWITCH

Mechanical Check

Using the test kit shown in Fig. IX-16 or Fig. IX-17, check the tripping pressure of the switch. This should be plus 1.9 to 2.1 in. of water.

1. With the engine shut down, hang the manometer or the differential pressure gage in a convenient place close to the pressure switch.
2. Firmly push in on the reset button to be sure the switch is in the RESET, or normal-operating, position.
3. When using test kit, Part 147X1475, hold the short piece of rubber tubing tightly against the vent hole in the control plate, Fig. IX-15. Then slowly work the rubber bulb to draw air from the upper side of the diaphragm.

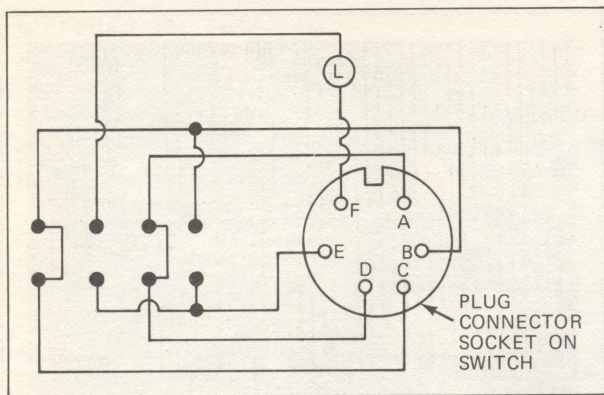


FIG. IX-18. INTERNAL WIRING DIAGRAM OF SWITCH — SHOWN IN RESET POSITION.

4. When using test kit, Part 147X1995, squeeze the plastic bottle to expel most of the air from within the bottle, then insert the plastic tip into the vent hole in the control plate, Fig. IX-17. Then allow the plastic bottle to expand and, in so doing, draw air from the upper side of the diaphragm.
5. Observe the indication on the manometer or the differential pressure gage when the switch begins to trip.
6. If indication is outside the correct tripping limits, replace the switch with a new or rebuilt switch.

Electrical Check

Disconnect the receptacle from the plug connector at the switch, so the pins in the plug connector are made accessible. Position the switch in both the RESET, or normal-operating, and TRIPPED positions. Using a test light or ohmmeter, check the internal circuitry of the switch. Refer to Figs. IX-18, IX-19 and Table IX-II. The switch can be tripped by drawing a slight vacuum at the vent hole (Fig. IX-15); it is reset by firmly depressing the reset button (Fig. IX-15).

TABLE IX-II, CONTINUITY CHECK

Pins	Circuit Condition With Switch In Position:	
	RESET	TRIPPED
D-A	Closed	Open
B-E	Open	Closed
B-F	Open	Closed*

*If open check pilot light bulb on the switch.

CYLINDER INLET PORTS

Remove clamp rings, manifold tubes, manifold bodies and heads, Fig. IX-20, to expose the cylinder inlet ports, Fig. IX-21. Note the degree of carbon build-up on all visible

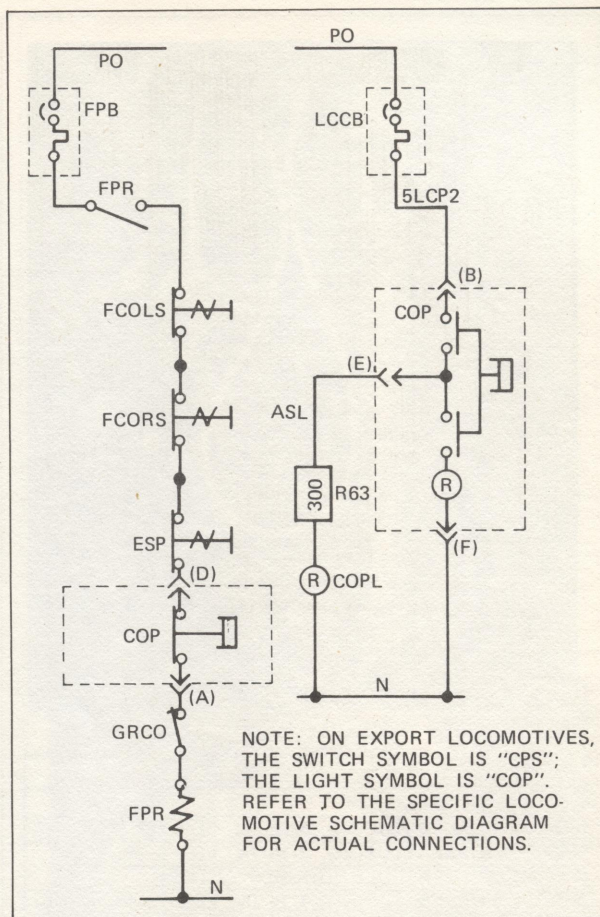


FIG. IX-19. TYPICAL LOCOMOTIVE SCHEMATIC DIAGRAM (PARTIAL) SHOWING CRANKCASE PRESSURE SWITCH CONNECTIONS.

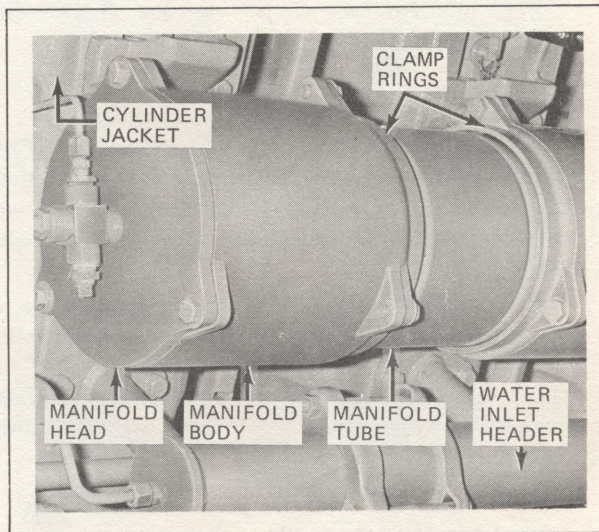


FIG. IX-20. ENGINE AIR INTAKE MANIFOLD.

FIG. IX-21, E-25560

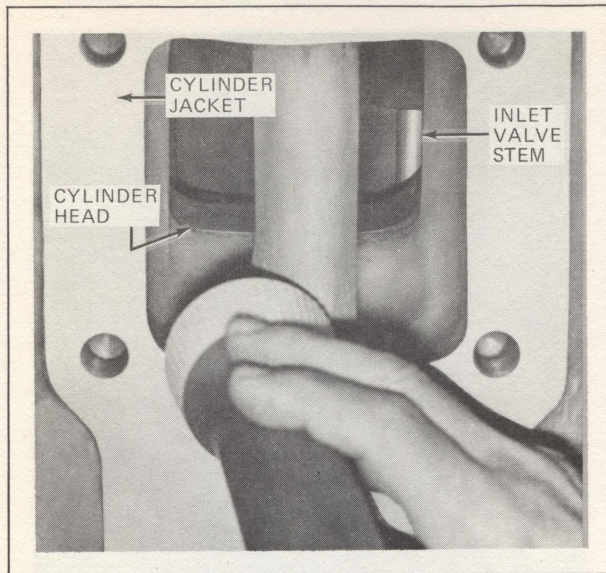


FIG. IX-21. CYLINDER INLET PORT.

surfaces of cylinder jacket, cylinder head and inlet valves. If carbon build-up exceeds 1/8 in. on any surface, clean the inlet ports of all cylinders in the engine using the walnut-shell cleaner, Part 147X1589.

CRANKSHAFT END-PLAY

With the engine shut down and crankcase inspection cover(s) removed, set up a magnetic base dial indicator, Part 147X1229. Attach the magnetic base to the main frame and position the indicator needle against the face of one of the counterweights. With a pry bar, move the crankshaft to its extreme forward and rear positions. Note the total movement of the dial indicator which is the crankshaft end-play or thrust clearance. If total clearance exceeds 0.030 in., renew thrust collars.

NOTE: *Crankshaft end-play is most easily done immediately after shutting the engine down.*

GEAR TRAINS

Front

Remove the lube-oil fill (Fig. IX-3) from the left side of the forward-end cover. Thru the opening in the cover, Fig. IX-23, and while barring-over the engine, visually inspect all gear teeth for excessive wear, broken teeth and overheating (discoloration).

NOTE: *While lube-oil fill is removed, check the pump drive gear rubber-bonded coupling. See Pump Drive Gear Coupling section.*

FIG. IX-22, E-25561

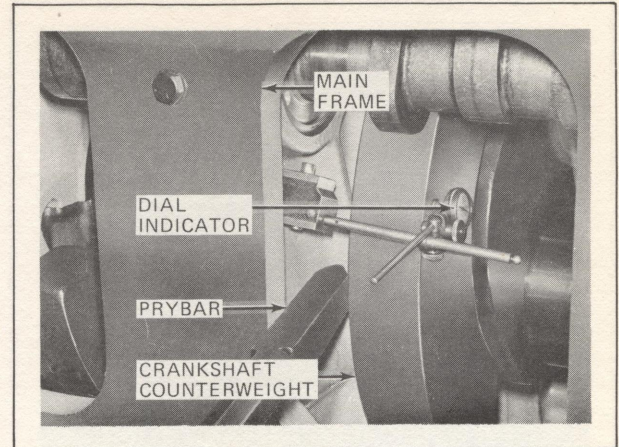


FIG. IX-22. CHECKING CRANKSHAFT END-PLAY.

Rear

Remove the camshaft gear cover (Fig. IX-15) from the rear left side of the main frame. Thru the opening in the main frame, Fig. IX-24, and while barring-over the engine, visually inspect all gear teeth for excessive wear, broken teeth and overheating (discoloration).

PUMP DRIVE GEAR COUPLING

Remove the lube-oil fill (Fig. IX-3) from the left side of the forward-end cover. Thru the opening in the cover, Fig. IX-25, apply a pry bar and gently rotate the gear on its hub 1/32 to 1/16 in. When the force on the pry bar is removed, the gear will quickly return to its original position if the rubber-bonded coupling is intact. A second, and better check, requires a flashlight and mirror. Work thru the opening, Fig. IX-26, in the forward-end cover and view the

FIG. IX-23, E-25562

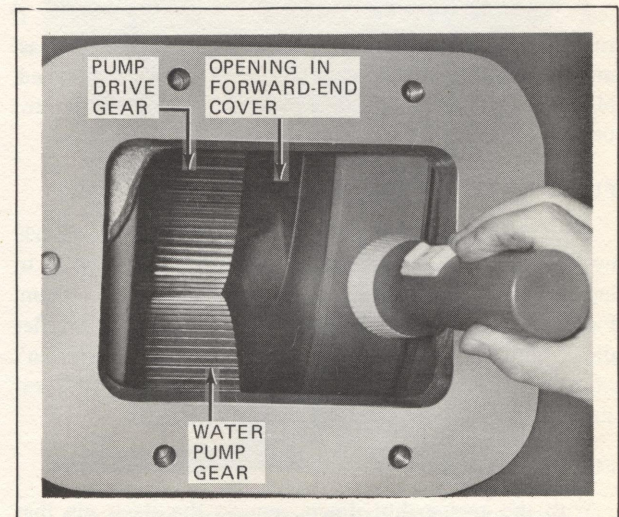


FIG. IX-23. CHECKING FRONT GEAR TRAIN.

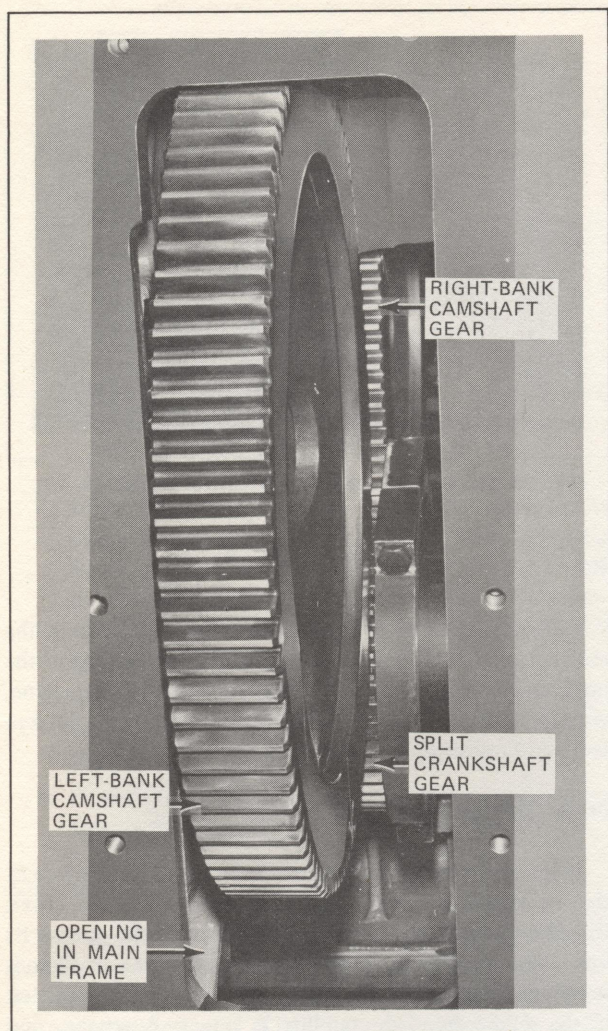


FIG. IX-24. CHECKING REAR GEAR TRAIN.

rear surfaces of the gear and hub, Fig. IX-27. If rubber-bonded coupling is intact (has not sheared), at least one set of match-mark numbers, Fig. IX-28, will be aligned. Misaligned numbers indicate a sheared coupling which must be replaced.

FUEL INJECTION EQUIPMENT

With the engine idling, "pop" test each injector nozzle by pulling out the fuel linkage shaft, Fig. IX-29, so as to increase the injection-pump rack setting 2 or 3 mm, Fig. IX-30. The resulting "high-pitch" explosion qualifies the pump and nozzle as satisfactory; a "low-pitch" explosion indicates a faulty pump and/or nozzle. This test also quickly identifies "stuck" pumps.

FUEL LINKAGE

With the engine shut down, remove the clevis pin that connects the bottom of the overspeed-derater link to the

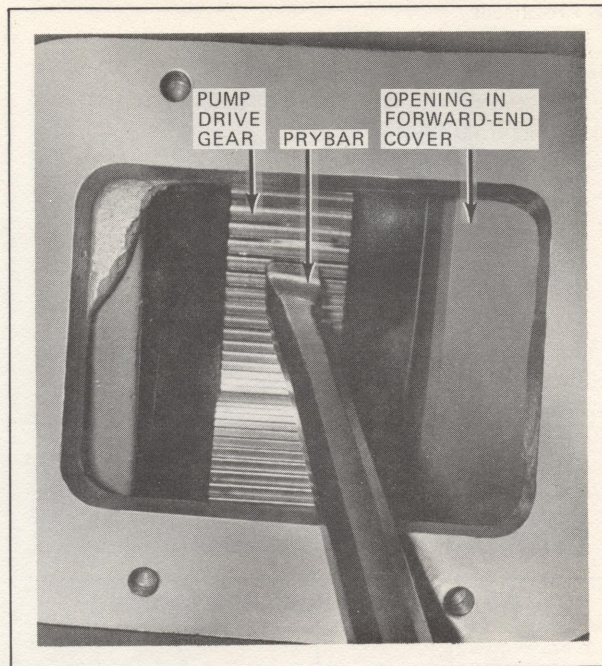


FIG. IX-25. CHECKING INTEGRITY OF RUBBER-BONDED COUPLING WITH A PRY BAR.

fuel linkage lever. With hand pressure applied to the fuel linkage lever, Fig. IX-31, rotate the short lay shaft which will operate the fuel linkage to all fuel injection pumps. Rotate lay shaft until full rack travel is achieved, then reverse the rotation until rack stop pins contact the faces of the calibration screws.

If fuel linkage cannot be moved thru its complete travel as outlined above, disconnect parts of the linkage, as required, until the source of the bindage is found and corrected.

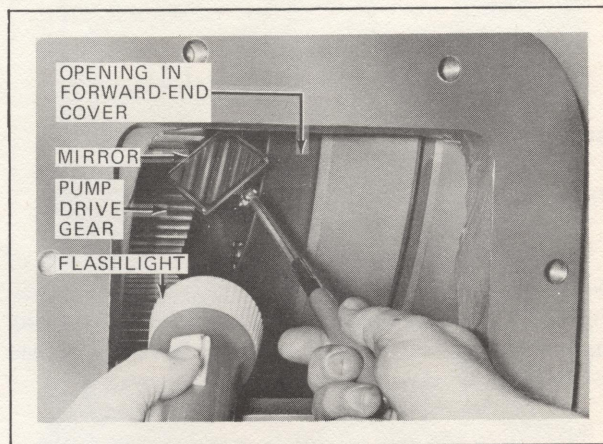


FIG. IX-26. CHECKING PUMP DRIVE GEAR MATCH MARK NUMBERS.

FIG. IX-27, E-25566

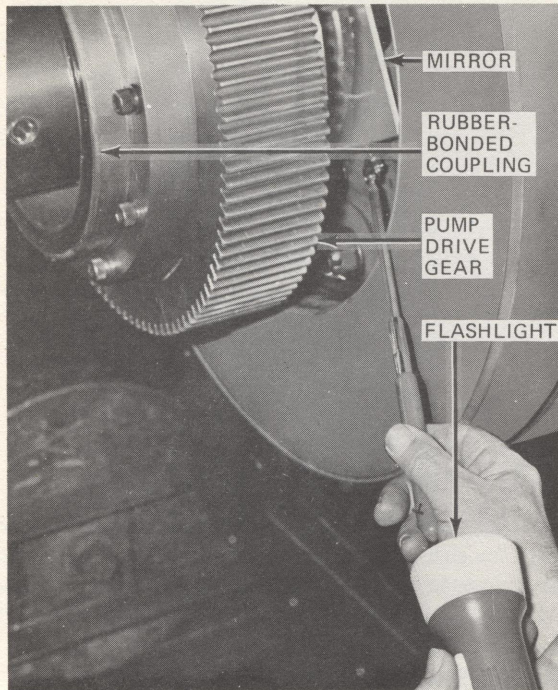


FIG. IX-27. CHECKING PUMP DRIVE GEAR MATCH MARK NUMBERS.

After fuel linkage has been moved thru its complete travel, check each fuel injection pump by pulling out the rack (Fig. IX-29) and allowing the spring to return it to the zero mm position. Note that no control rack stays stuck in the maximum fuel position.

FIG. IX-29, E-25568

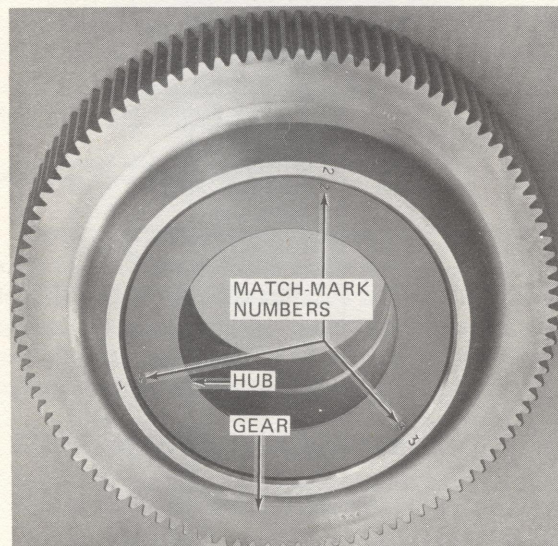


FIG. IX-28. MATCH-MARK NUMBERS ON BACK (FRAME) SIDE OF HUB AND GEAR.

FIG. IX-30, E-25569

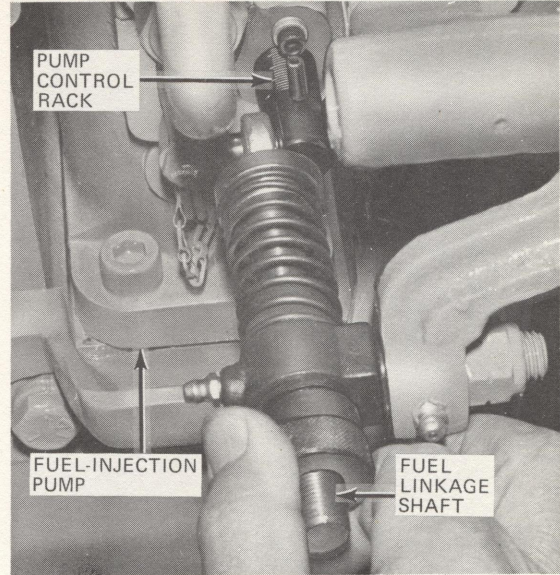


FIG. IX-29. "POP" TESTING TO IDENTIFY GOOD, OR BAD, FUEL INJECTION EQUIPMENT.

LEAKS

With engine idling, inspect the engine externally for system leaks. Lube-oil and fuel-oil leaks will be evident by oily films or flow patterns. Cooling-water leaks will be evident by discoloration due to the water treatment. Exhaust-gas leaks cause discolored or peeled paint or leave a carbon film adjacent to the leak.

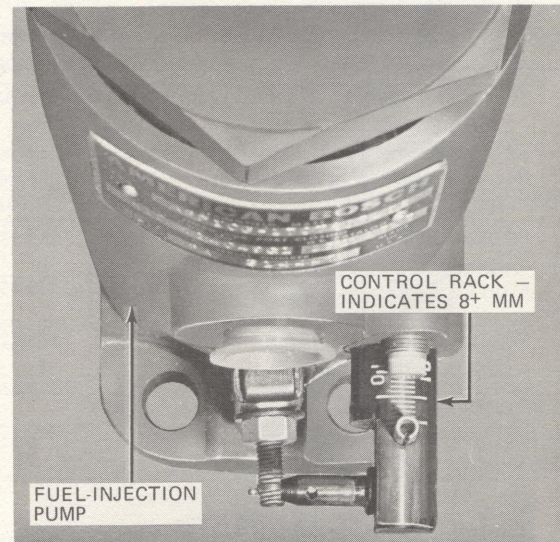


FIG. IX-30. INJECTION PUMP RACK SETTING DURING "POP" TEST.

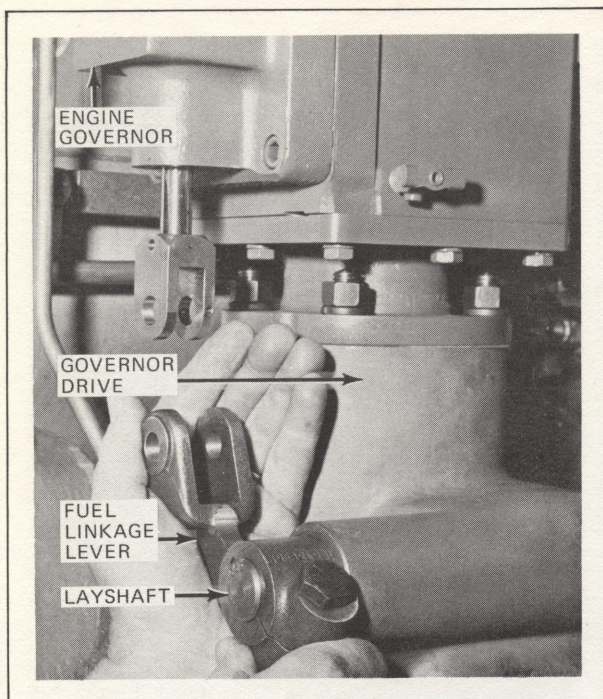


FIG. IX-31. MANUALLY MOVING FUEL LINKAGE.

NOISES

With engine idling, listen for excessive or unusual noises at each cylinder and at the exhaust stack. In addition to detecting such faults as excessive valve tappet clearance (clicking noise) or a defective exhaust valve (a louder-than-normal, periodic noise out the stack), this type of inspection may also identify other engine defects, such as a pounding (excessive clearance) bearing.

EXHAUST GAS

With engine idling, observe the color of the exhaust gas. A clear to light grey color is desirable. A blue cast indicates excessive lube oil in the exhaust gas, and this could result from scored cylinder liners, faulty piston rings, or bad turbocharger bearings and/or seals. A white cast indicates water in the exhaust gas which is probably caused by a defective top liner seal in a cylinder assembly. The white cast could also be a temporary condition due to the engine running cold.

ADJUSTMENTS

FUEL PUMP RACK SETTING

General

The following instructions cover the fuel pump rack settings for eight, twelve, and sixteen-cylinder engines. The settings given in Table IX-III are for eighth notch, full load (0.344 in. governor power piston gap) and for IDLE (31/32 to 1-1/32 in. power piston gap).

The settings given in the table will give the approximate horsepower expected from the engine; the precise horsepower output can only be achieved by load testing the engine and by fine adjustment of the control racks as required.

Fuel Header Pressure

The rack setting values given in Table IX-III are for locomotives whose fuel header pressure is set at 39-41 psi at IDLE engine speed.

TABLE IX-III

Engine Type	Locomotive Application	Horsepower to Generator for Traction*	Notch 8 Engine Speed (rpm)	Notch 8 Tachometer Speed (rpm)	Injection Pump Size**	Recommended Fuel Lever and Length (in.)	Rack Settings (mm)	
							△Engine Hot, N8 Speed, Full Load, 0.344 in. Gap	Idle Speed, 31/32 to 1-1/32 in. Gap□
FDL8	B18-7	1800	1045-1057	1553-1568	Large	132X1318 (3.250)	24,25-24,75	5,50-6,00
FDL12	B23-7 C23-7	2250	1045-1057	1553-1568	Large	132X1106-4 (2.375)	19,50-20,00	↑ ↓
FDL12	B28-7 C28-7	2750	1045-1057	1553-1568	Large	132X1317 (2.968)	22,5-23,0	
FDL16	B30-7 C30-7	3000	1045-1057	1553-1568	Large	132X1251-1 (2.484)	19,50-20,00	
FDL16	B36-7 C36-7	3600	1045-1057	1553-1568	Large	132X1276-1 (2.843)	22,25-22,75	5,50-6,00

*Shown on the locomotive nameplate.

**A large pump is identified as a Part 132X1254-1 (Bendix) or Part 132X1343 (Bosch) pump.

△NOTE: Experience shows that in many cases the rack readings on an engine, hot and running at full load, will average 0,5 mm higher than for the same engine cold and shut down.

□When the engine is running at IDLE speed, power-piston gap will vary due to variance in locomotive auxiliary loads.

FIG. IX-32, E-22594

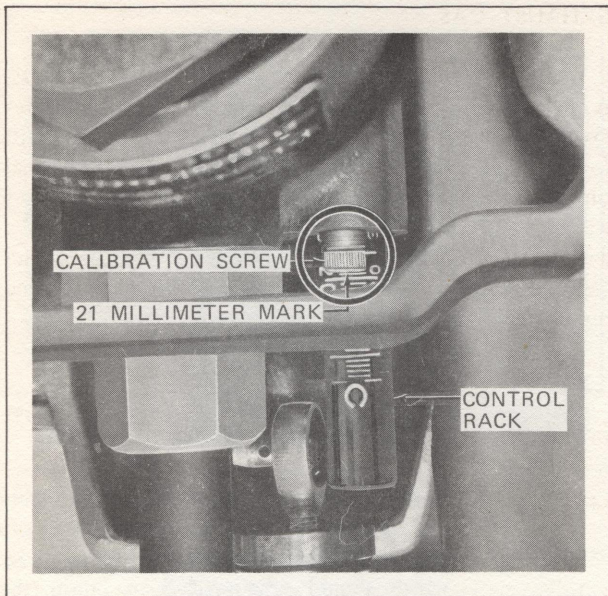


FIG. IX-32. CORRECT METHOD OF OBSERVING RACK READING — 21+ MM READING SHOWN.

NOTE: The header pressure at full speed and full load will be lower than the pressure at IDLE. This lower pressure varies with the engine horsepower output, and with the condition of the fuel strainer, fuel filter and fuel transfer pump.

Reading Rack Setting

To correctly read a rack setting, always observe the control rack at a right angle to the direction of rack movement. Observing from an oblique angle will give an erroneous reading. The rack reading is obtained by sighting across the face of the calibration-screw head toward the etched indications (in millimeters) on the control rack, Fig. IX-32.

Adjusting Fuel Pump Racks

The racks of all fuel-injection pumps on an engine must be set to match the governor power piston gap and must be identical within the limits specified in Table IX-III. This is best accomplished with the engine shut down and one of the following safeguards used to prevent cranking the engine during the adjustment procedure:

1. Block the starting contactors OPEN.
2. Disconnect the electrical connector from the governor drive, Fig. IX-33.
3. Remove the barring-over cover from the governor drive, Fig. IX-33.

FIG. IX-33, E-23479

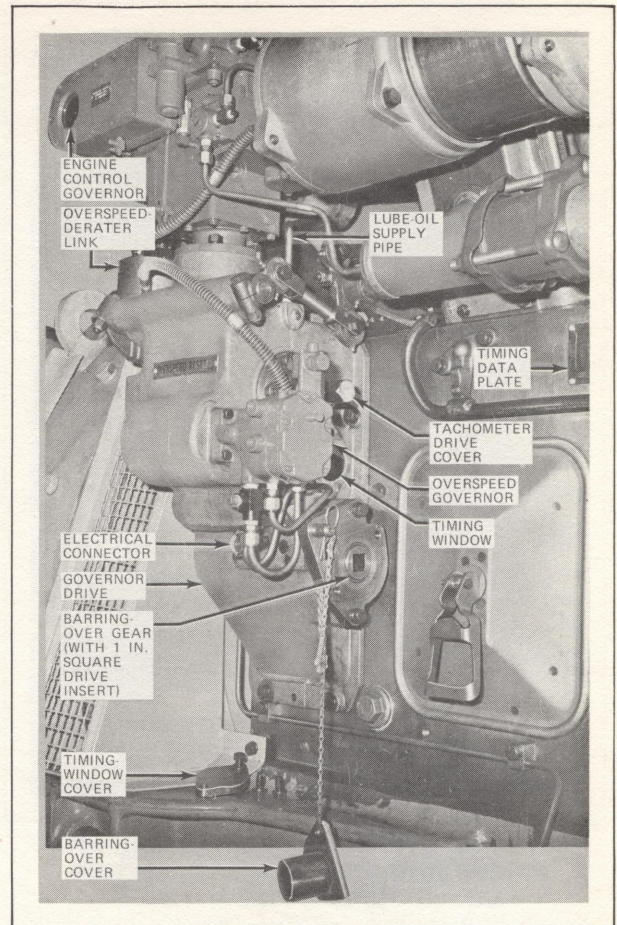


FIG. IX-33. GOVERNOR DRIVE MOUNTED ON ENGINE.

In general, the governor power piston and the fuel linkage first must be set up to simulate a Notch 8, full-load condition, after which each individual pump rack is adjusted to the correct millimeter setting.

Check and adjust racks using the following procedure:

1. Set up the governor power piston and fuel linkage as follows:
 - a. Install the overspeed link compressor, Part 147X1580, on the side of the governor drive gear unit, Fig. IX-34.
 - b. Turn compressor screw up to apply a force against the bottom of the overspeed-derater link to compress the link and raise the power piston. Raise the piston until the 0.344-in. gap gage, Part 147X1296, is firmly clamped and the overspeed-derater link is fully compressed. This will be evident when the top edge of the indicator is aligned with the lower groove on the outer casing.

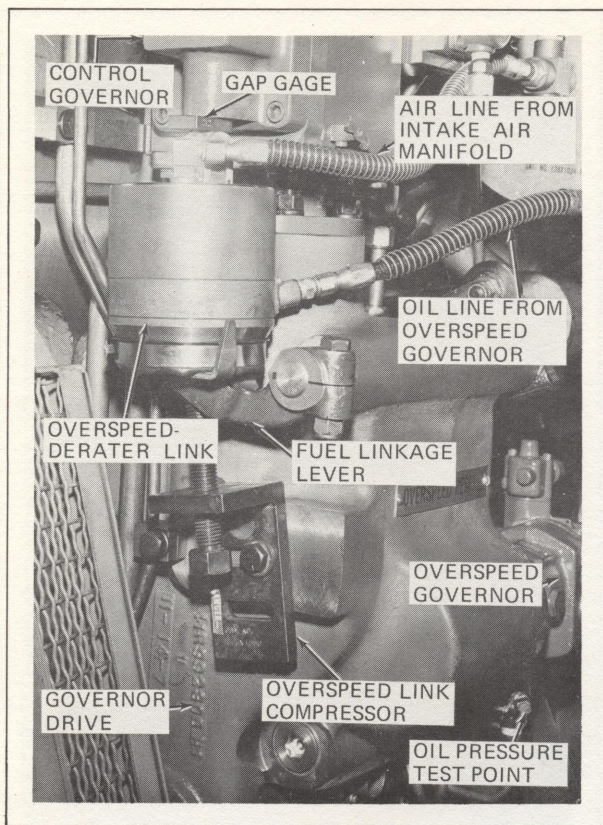


FIG. IX-34. OVERSPEED-DERATER LINK WITH ENGINE SHUT DOWN AND RACK-SETTING TOOLS APPLIED.

NOTE: To avoid the physical effort required to compress the link, remove the oil inlet hose from the link and supply compressed air or hydraulic fluid (max. 200 psi pressure) to the oil inlet fitting.

2. Check the Notch eight (N8) full load setting of all pump racks. Those racks with settings different from the values shown in Table IX-III must be reset using one of the following methods:

- A. If pumps are operated by a nut and locknut type adjustable link, Fig. IX-35:
 - a. Using two wrenches, hold the adjusting nut and loosen the locknut.
 - b. Turn the adjusting nut to lengthen or shorten the link so the rack shows the correct millimeter setting.
 - c. Using two wrenches, hold the adjusting nut and tighten the locknut.
 - d. Repeat Steps a, b and c in Item A above for all pumps needing adjustment.

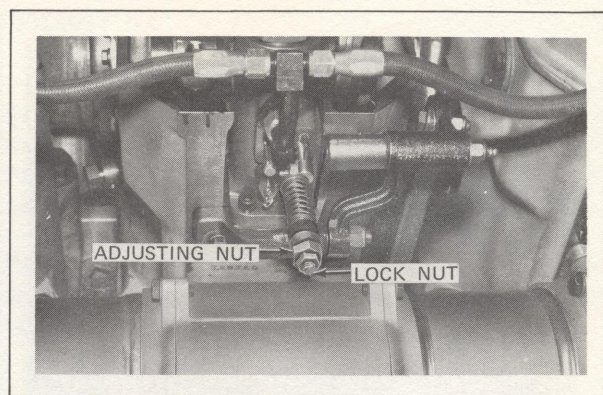


FIG. IX-35. FUEL PUMP RACK ADJUSTMENT — NUT AND LOCKNUT TYPE ADJUSTABLE LINK.

- e. Back off the compressor screw completely and remove the link compressor and gap gage used for this operation. Check all racks, which should now read 0 to 3 mm, the correct reading for the engine SHUTDOWN condition.

WARNING: Under no condition should the engine be started with the overspeed link compressor still in place. This could result in destruction of the engine and injury to personnel in the vicinity.

- B. If pumps are operated by a round knurled nut type adjustable link, Fig. IX-36:

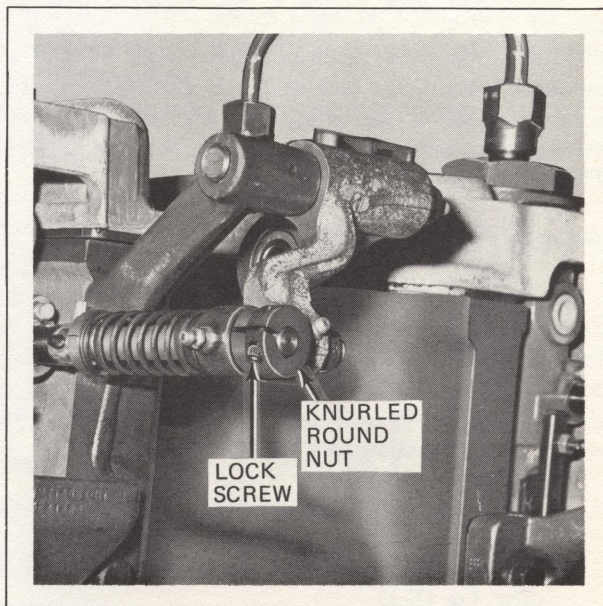


FIG. IX-36. FUEL PUMP RACK ADJUSTMENT — ROUND, KNURLED NUT-TYPE ADJUSTABLE LINK.

FIG. IX-34, E-21096

FIG. IX-35, E-18363A

FIG. IX-36, E-25339

FIG. IX-37, E-22595

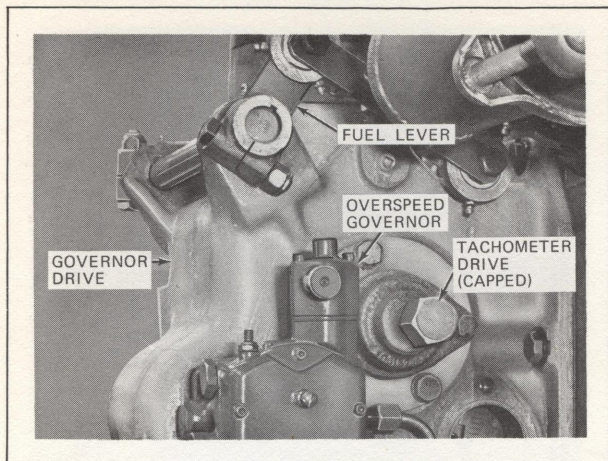


FIG. IX-37. FUEL LEVER.

- Loosen the lock screw using a 9/64-in. hex key wrench.
- By hand only, turn the round knurled nut to lengthen or shorten the link so the rack shows the correct millimeter setting.
- Tighten the lock screw using a 9/64-in. hex key wrench.
- Follow the same instructions given under Steps d and e in Item A above.

Fuel Linkage

The fuel linkage assemblies used on GE engines are, in general, quite similar and differ only in the following manner:

- Quantities of parts (vary with number of cylinders)
- Length of fuel lever, Fig. IX-37.

The fuel lever must be of such length that it will produce BOTH the maximum-horsepower control-rack value and the idle-speed control-rack value while the governor power piston moves thru its uniform length of travel; that is, from the IDLE position when the power-piston gap is 31/32 in. to 1-1/32 in. to the FULL SPEED, FULL POWER position when the gap is 11/32 (0.344) in.

Table IX-III gives the part number and center-to-center length for the fuel lever recommended for each locomotive application.

FUEL PUMP TIMING

Pump Variations

Several types of fuel injection pumps are in use on GE engines. There is, however, only one major difference with respect to timing. All Bendix pumps and all Bosch pumps

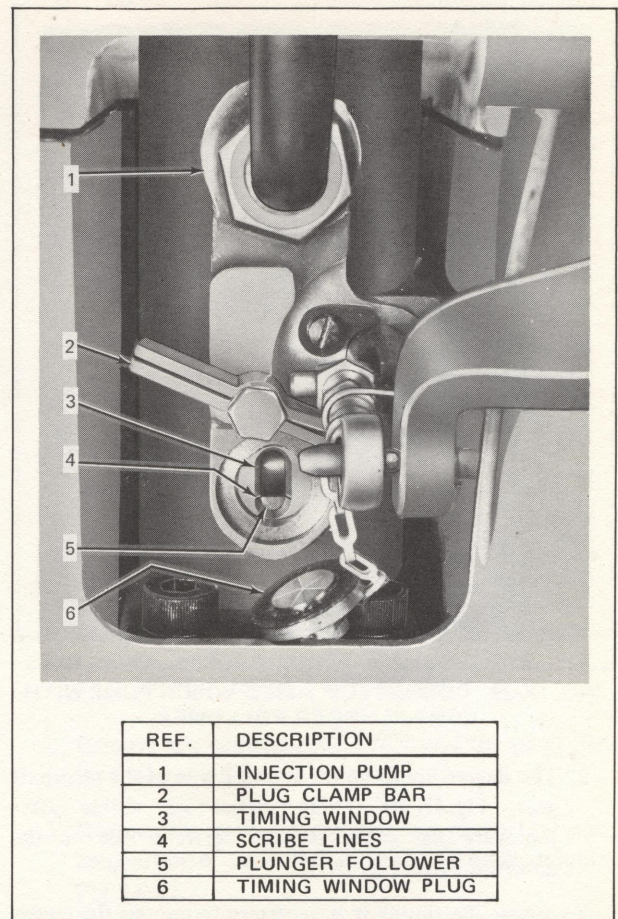


FIG. IX-38. CORRECTLY TIMED BENDIX PUMP OR BOSCH PUMP WITH SHORT PLUNGER FOLLOWER.

applied prior to early 1978 have a short plunger follower. Any of these pumps is correctly timed when the top of the plunger follower is aligned with the scribed lines in the pump timing window, Fig. IX-38.

Beginning in early 1978, Bosch pumps use a long plunger follower. A pump of this type is correctly timed when the scribed line on the side of the plunger follower aligns with the scribed lines in the timing window, Fig. IX-39.

It should be noted that the plunger follower in the later Bosch design will be visible even when the plunger follower is at its lowest position. This is not true of the other style of pump.

Pump Timing

When timing the fuel injection pumps, it is necessary to refer to the following indicating marks:

- The scribed lines at the pump timing windows, Figs. IX-38 and IX-39. These lines are visible after the timing covers on the front of the pumps are unclamped and removed.

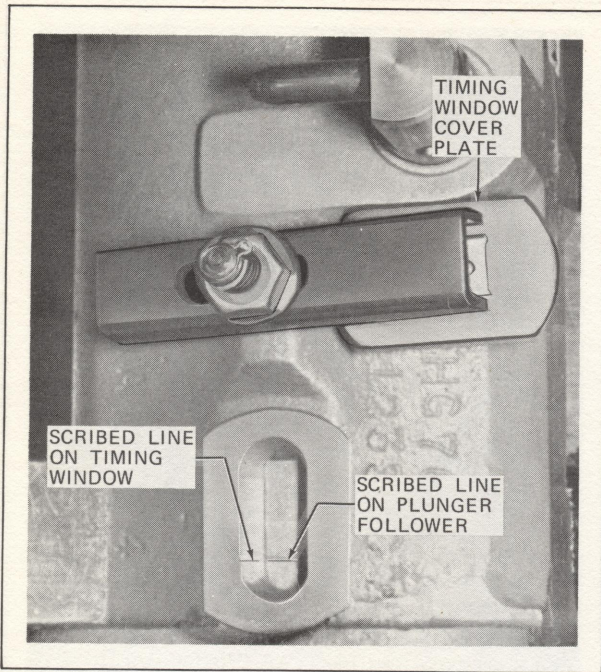


FIG. IX-39. CORRECTLY TIMED BOSCH PUMP WITH LONG PLUNGER FOLLOWER.

2. The degree marks on the forward side of the camshaft gear, Fig. IX-40. These marks are visible after removing the cover on the forward side of the governor drive, Fig. IX-41.

To adjust the timing it is necessary to remove the covers which seal the pump tappet rod compartment, Fig. IX-42. These covers are located on the lower front face of each cylinder.

The engine is barred-over by rotating the barring-over gear in the governor drive. This gear is made accessible by removing the cover from the forward side of the governor

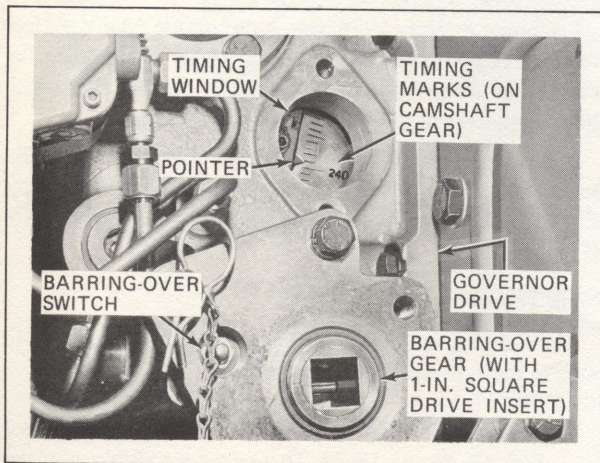


FIG. IX-40. GOVERNOR DRIVE WITH COVERS REMOVED.

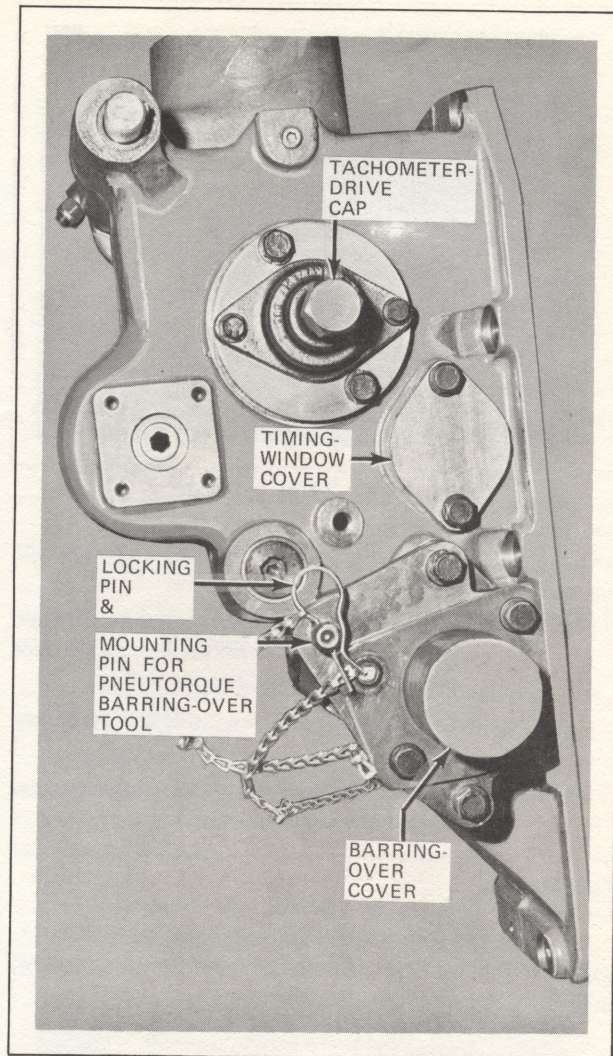


FIG. IX-41. ASSEMBLED GOVERNOR DRIVE, FORWARD SIDE.

drive, Fig. IX-41. After moving the gear inward into engagement with the camshaft gear, apply either a ratchet wrench with a 1-in. square drive, Fig. IX-43, or an air-operated wrench, Fig. IX-44.

CAUTION: The use of an impact wrench is not recommended for this operation, since internal damage may result.

CAUTION: Incorrect pump timing can cause excessive pump plunger travel, which may result in severe damage to the pump.

FIG. IX-39, E-24779

FIG. IX-40, E-24341

FIG. IX-41, E-23484

FIG. IX-42, E-9979B

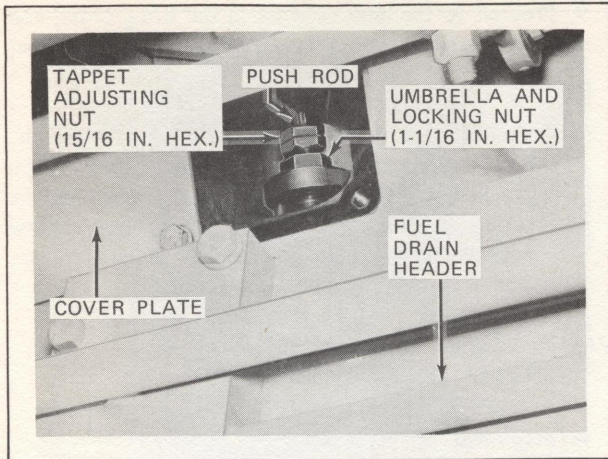


FIG. IX-42. FUEL INJECTION PUMP TAPPET ROD ADJUSTMENT.

Pump timing is accomplished in the manner outlined below.

The No. 1 right cylinder pump for a 16-cylinder engine is used as an example and is a good starting point to use when all engine pumps are to be timed.

NOTE: *Tappet settings on inlet and exhaust valves of a cylinder can be checked and, if necessary, readjusted while the fuel pump on the cylinder is being timed.*

1. Back off the compression-release plugs one full turn on all cylinders.

FIG. IX-43, E-24343

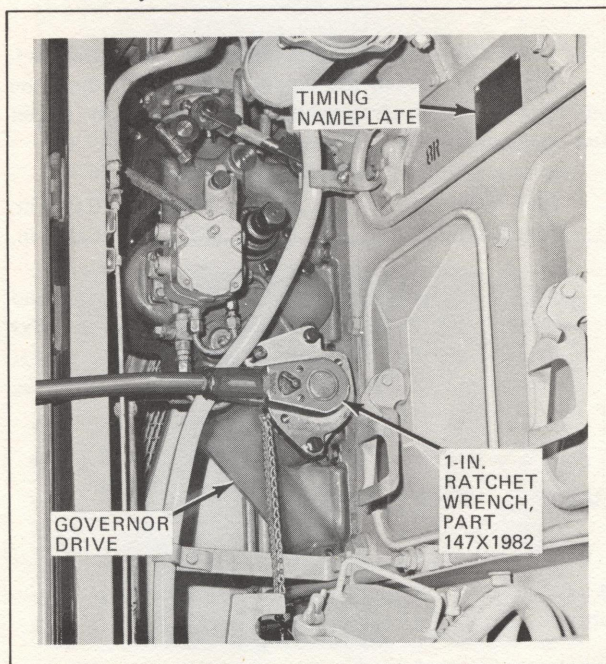


FIG. IX-43. BARRING-OVER ENGINE USING A 1-IN. RATCHET WRENCH.

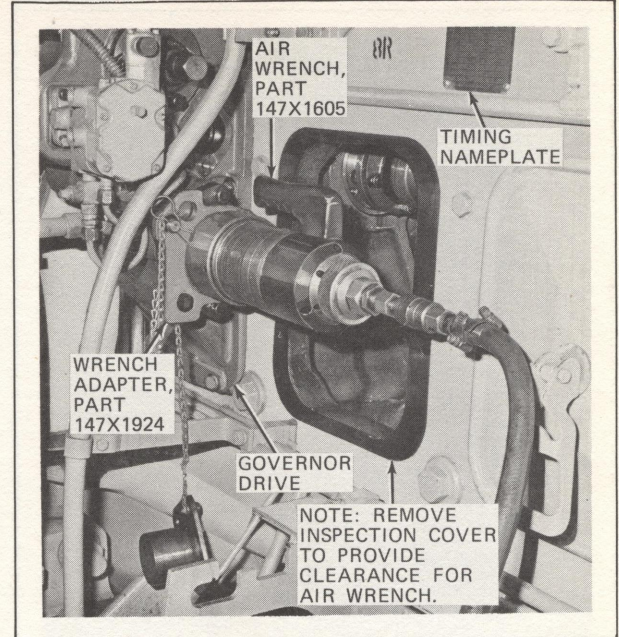


FIG. IX-44. BARRING-OVER ENGINE USING THE PNEUTORQUE AIR WRENCH.

2. Remove the cylinder-head covers and the plugs from the fuel-pump timing windows.
3. Remove the covers which seal the pump tappet-rod compartment near the bottom of each cylinder, Fig. IX-42.
4. Use the ratchet wrench or air-operated wrench, and slowly bar the engine over in its normal direction of rotation until the pointer in the timing window aligns with the 348.5-degree line. Refer to Figs. IX-40 and IX-45.
5. Assure all valves are closed on the 1-R cylinder (compression stroke). If the valves are closed, a small amount of free movement will be noted by manually moving the rocker arms. Another check is to observe the radial position of the fuel and valve cams for the particular cylinder. If the cylinder is on its compression stroke, the valve crosshead rollers will be off the lobe and on the base circle of the cam. The fuel crosshead roller will be rising on the lobe of its cam.

NOTE: *While this operation is not mandatory, it is recommended since it assures the integrity of the camshaft assemblies and the engine firing order.*

6. Adjust the fuel-pump tappet nut on the 1-R cylinder until the top edge of the plunger follower is exactly aligned with the scribed marks on the sides of the

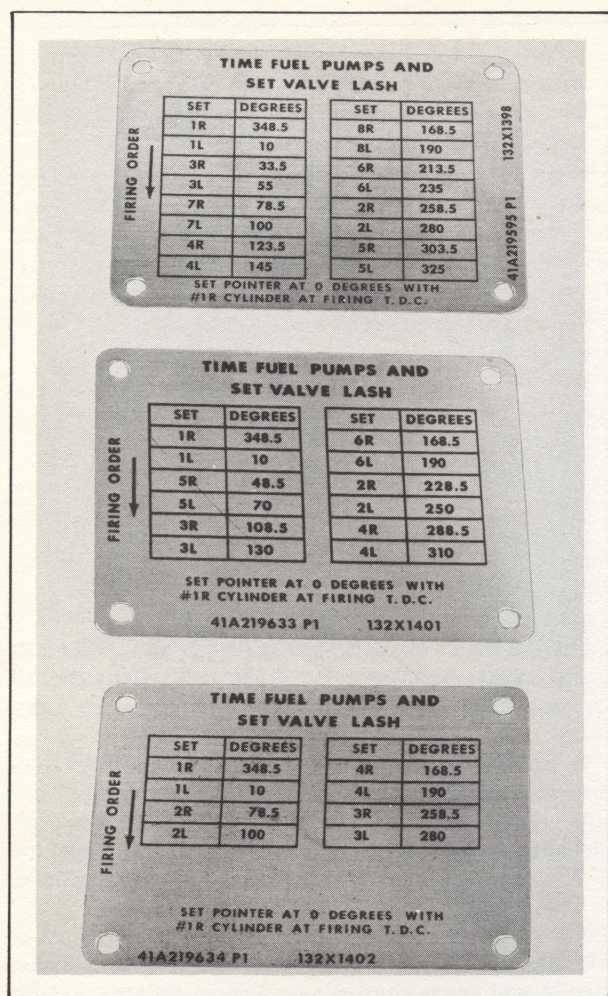


FIG. IX-45. TIMING NAMEPLATES FOR 8, 12 AND 16-CYLINDER ENGINES.

fuel-pump timing window, Fig. IX-38, or the scribed line on the long plunger follower is aligned with the scribed lines on the sides of the timing window, Fig. IX-39.

- Lock the tappet nut securely and recheck the alignment of the pump timing marks.

CAUTION: Use two wrenches, when tightening: 1-1/16 in. on the umbrella locknut, and 15/16 in. on the tappet nut. Failure to do so will cause overtightening against the guide pin of the tappet rod. This will distort or damage the bronze tappet guide.

- Refer to the timing nameplate, Fig. IX-45, and following the timing order given on the nameplate, bar the engine to the degree value for timing the 1-L fuel pump. Time the 1-L pump by performing Steps 5, 6 and 7 above.

- Proceed to the next cylinder in the firing order, and repeat until all have been timed. Be sure each tappet nut is locked before leaving it.

- After all the pumps have been timed, replace the tappet-rod adjustment covers, cylinder-head covers, and fuel-pump timing-window plugs. Remove the barring-over tool and replace the timing window cover and barring-over cover on the governor drive. Tighten the compression-release plugs.

VALVE TAPPET CLEARANCE

NOTE: This operation is most efficiently accomplished if it is done in conjunction with fuel-pump timing. See Fuel Pump Timing section.

- Properly position the piston in the cylinder. Remove the timing-window cover and the barring-over cover from the governor drive, Fig. IX-41. Move the barring-over gear inward into engagement with the camshaft gear, then apply either a 1-in. ratchet wrench, Fig. IX-43, or an air-operated wrench, Fig. IX-44, to the barring-over gear. Bar-over the engine to rotate the camshaft until the correct timing (degree) mark for the cylinder being worked on, as specified on the timing nameplate, Fig. IX-45, is exactly aligned with the pointer, Fig. IX-40. Check that both inlet and exhaust valves are closed, indicating that the piston is on the compression stroke.

- Using standard tools, Fig. IX-46, or the special tool, Fig. IX-47, loosen the tappet locknut and adjust the tappet screw to give the following valve tappet clearances:

Inlet Valves 0.018 to 0.020 in.
Exhaust Valves 0.028 to 0.030 in.

Tighten all locknuts with 50-55 lb.-ft. of torque and recheck the clearance. Bar-over the engine to the next cylinder (in the firing order) and adjust the tappet clearances. Continue this procedure until all valve tappets have been properly adjusted.

LUBE-OIL RELIEF VALVE

With engine shut down, install a 0-180 psi pressure gage in one of the test points in the oil piping between the lube-oil pump and the oil cooler. Refer to Fig. X-2.

With the engine running and with cold lube oil, advance the Throttle as required and note the maximum pressure

FIG. IX-46, E-13113

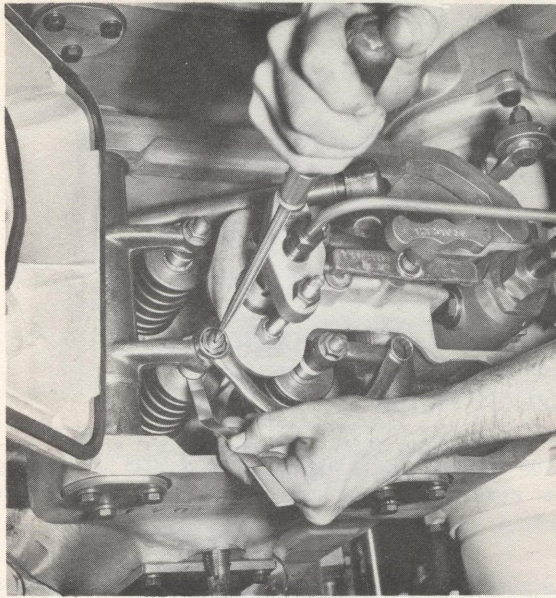


FIG. IX-46. ADJUSTING VALVE TAPPET CLEARANCE USING STANDARD TOOLS.

gauge indication which is the relief valve setting. This should be 135 to 140 psi.

To adjust the relief valve, Fig. IX-48:

1. Remove the hood from the valve.
2. Loosen the pressure screw locknut.
3. Turn the pressure screw in (clockwise) to raise the operating pressure; turn the pressure screw out (counterclockwise) to lower the operating pressure.

FIG. IX-48, E-25591

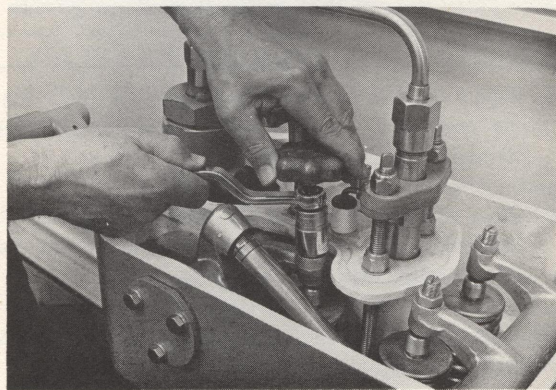


FIG. IX-47. ADJUSTING VALVE TAPPET CLEARANCE USING SPECIAL TOOL, PART 147X1042.

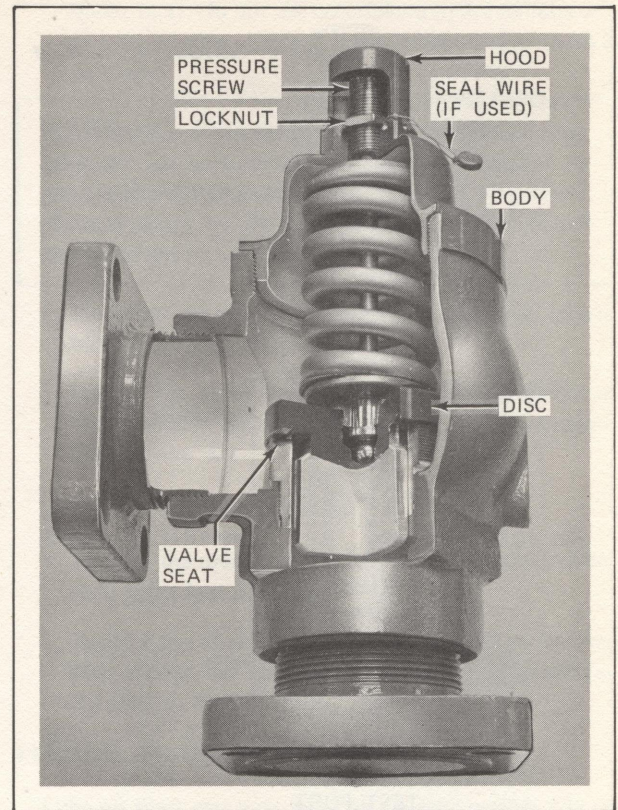


FIG. IX-48. LUBE-OIL RELIEF VALVE, CUTAWAY VIEW.

4. After achieving the correct operating pressure, as indicated on the pressure gage, lock the pressure screw with the locknut and replace the hood.
5. Shut down the engine and remove the test pressure gage.

FUEL-OIL RELIEF VALVE

1. Install a calibrated 100 psi pressure gage in one of the test ports, Fig. IX-49.
2. Cap off the fuel header after it leaves the last injection pump. Refer to Fig. X-1.
3. Start the fuel transfer pump and observe the test pressure gage which should indicate 74 to 76 psi. Battery voltage during this test should be approximately 64 volts.

CAUTION: DO NOT START OR RUN THE ENGINE FOR THIS TEST.

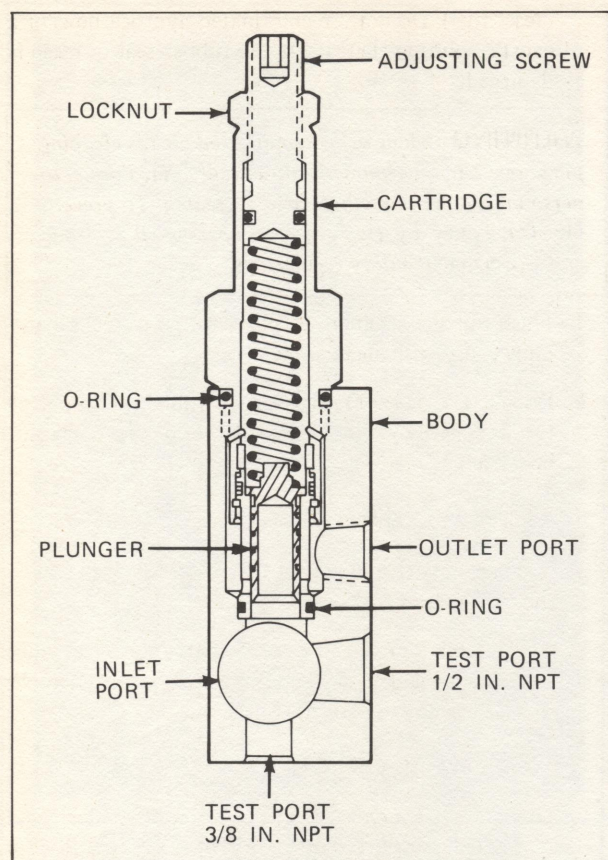


FIG. IX-49. FUEL-OIL RELIEF AND REGULATING VALVE.

4. To correct the valve setting, loosen the adjustment locknut, and turn the adjusting screw IN to raise the pressure. Turn the screw OUT to lower the pressure.
5. Tighten the locknut. Check the gage reading and stop the fuel transfer pump.
6. Remove the test gage and restore the piping to normal.

FUEL-OIL REGULATING VALVE

1. Install a calibrated 100 psi pressure gage in a test port, Fig. IX-49.

NOTE: Be sure the fuel strainer element has been cleaned and a new element has been installed in the filter housing.

2. Start the fuel transfer pump and engine. With the engine operating at idle speed, read the pressure indicated on the test gage. It should read approximately 38 to 42 psi.

3. Loosen the adjustment locknut. Adjust the screw to set the pressure. Turn the screw IN to raise the pressure or OUT to lower the pressure.
4. Tighten the adjustment locknut. Check the gage reading.
5. Stop the engine and fuel transfer pump, remove the test gage and replace the pipe plug.

REPLACEMENTS

FUEL-OIL FILTER

The fuel filter assembly consists of a steel can housing a filter element. It is connected to the fuel transfer pump discharge opening.

A gradual drop in fuel flow and header pressure indicates the fuel strainer or fuel filter has become restricted and should be either cleaned or replaced, respectively.

1. Shut down engine and fuel transfer pump.
2. Partially open filter cover then open spring-loaded valve beneath filter tank. Hold open for one minute. Fuel in the filter case will drain back to the main tank.
3. Remove filter cover. Remove and discard used filter element.
4. Flush filter tank with clean fuel oil. Again hold the drain valve open until tank is empty. Blow dry with shop air.

WARNING: Personal injury may result if proper eye protection is not worn when blowing with compressed air.

5. Wipe a small amount of clean lube oil on the O-ring in the end of a new GE Part 132X1250 fuel filter element. Install the element.
6. Close and seal the lid of the filter housing, applying new O-ring cover gasket if necessary. Make sure drain valve is fully closed.
7. Start the fuel transfer pump. When fuel pressure gage reads approximately 40 psi, start the engine.
8. Inspect entire fuel system for any leaks and make corrections as necessary.

FIG. IX-50, E-25377

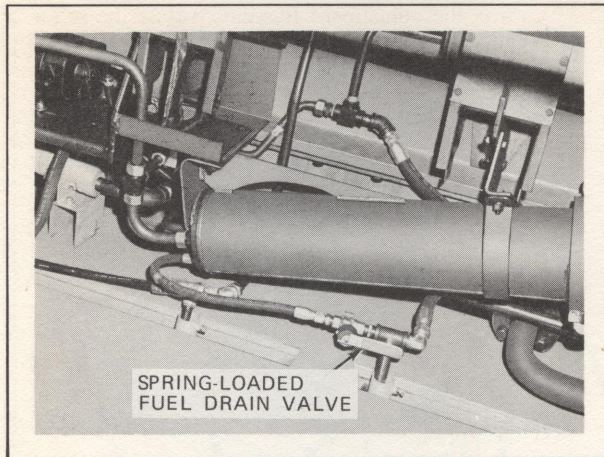


FIG. IX-50. TYPICAL FUEL DRAIN VALVE ARRANGEMENT.

FUEL-OIL STRAINER

Whenever a fuel-oil filter is replaced, the fuel-oil strainer should be inspected and cleaned. Beginning in 1978, some strainers having a coarser mesh strainer element were installed in the fuel system. This was done to keep the strainer from waxing up during cold weather operation. It can be regarded as a "throwaway" part. It may, of course, be cleaned if desired. The element will fit either bottom-opening or top-opening strainer housings.

FIG. IX-51, E-25407

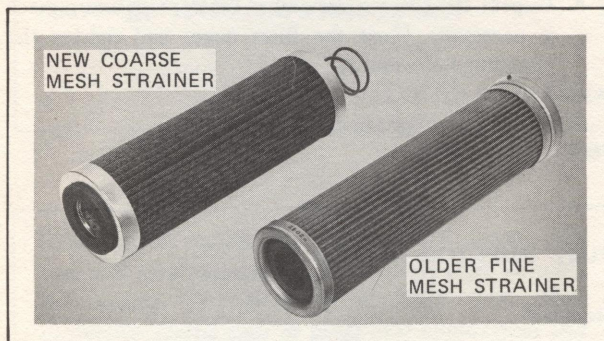


FIG. IX-51. TYPES OF STRAINER ELEMENTS.

Cleaning Elements

1. Remove the drain plug from the strainer housing to drain it.
2. Loosen the wing nuts on the strainer cover and remove the strainer element. If it is a sump-type strainer, remove two bolts, remove sump and drain it.
3. Flush the element in a cleaning solution and blow dry with clean air. If the element is a coarse screen type, flush it only with a petroleum solvent (kerosene,

FIG. IX-52, E-25435

diesel fuel). Do not use chlorinated hydrocarbons or a caustic solution. Discard if the rubber seal or mesh is damaged.

WARNING: When using compressed air for cleaning purposes, an environment potentially hazardous to personnel in the immediate area is created. To prevent physical injury by flying debris, observe all Railroad and Government safety regulations.

4. Flush out the strainer housing with clean fuel oil and blow it dry with clean air.
5. Inspect the cover O-ring and the rubber grommet of the fine-mesh type strainer. If either item is damaged, install a new one.
6. Replace the cleaned element.
7. Replace the drain plug if of that type. Fill the strainer shell with clean fuel oil.
8. Replace the strainer cover and tighten the cover wing nuts evenly and carefully. If sump type, reassemble the shell to the top cover.

LUBE-OIL FILTER ELEMENTS

Lube-oil filter elements must be replaced periodically on a planned schedule or if the pressure drop across the filter is too high a value. Water in the lube-oil system will permanently affect the performance of filter elements. Thus if a leaking lube-oil cooler or engine cylinder is changed out, the lube-oil and filter should be changed.

Changing Elements

1. Remove the vent plug, Fig. IX-54, and open the filter drain-back valve, Fig. IX-56. Drain the filter case.

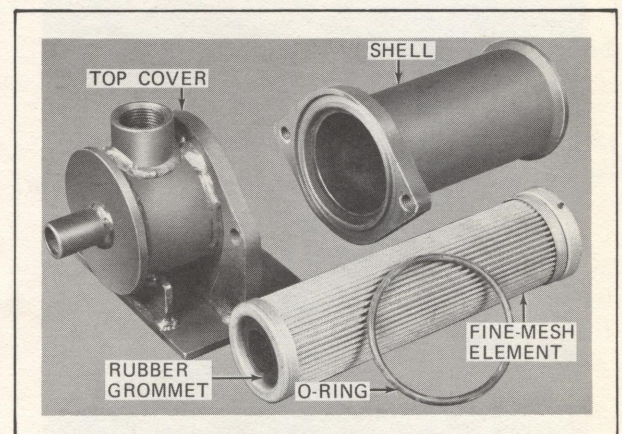


FIG. IX-52. DETAILS OF SUMP-TYPE STRAINER AND FINE-MESH ELEMENT.

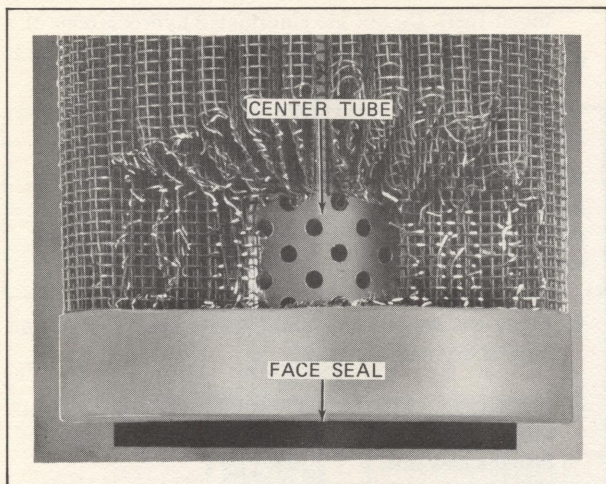


FIG. IX-53. CUTAWAY OF COARSE-MESH ELEMENT.

2. Close the drain-back valve.
3. Loosen the filter cover clamps and open the hinged cover.
4. Remove the wing nuts and element holddown plates. Inspect the elements for metal particles before discarding.

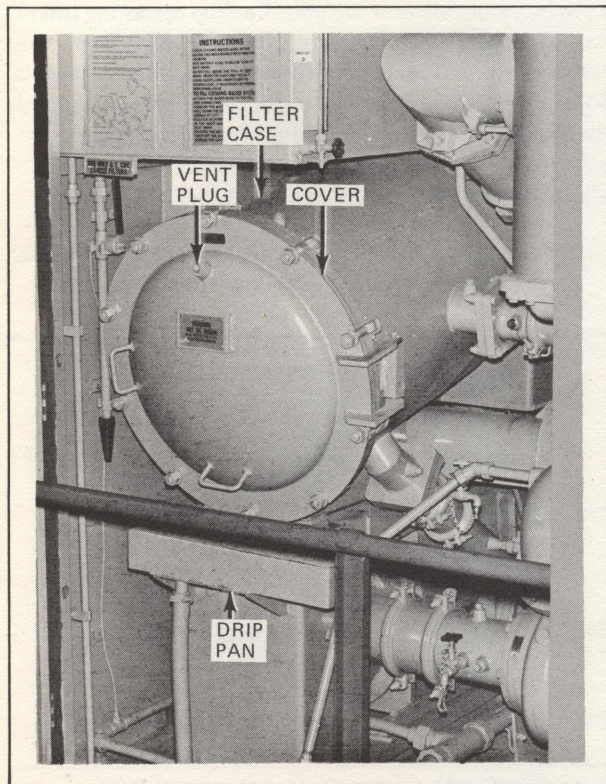


FIG. IX-54. LUBE-OIL FILTER.

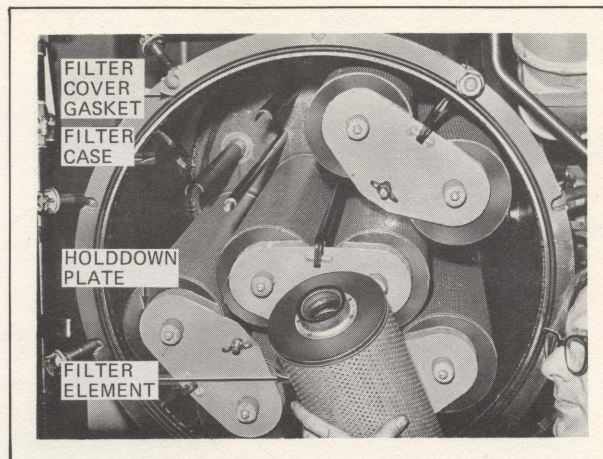


FIG. IX-55. RENEWING FILTER ELEMENTS.

5. Wipe the inside of the case clean.
6. Install new filter elements, Fig. IX-55.

NOTE: Do not use cotton waste filters.

7. Install the element holddown plates and tighten the wing nuts **HAND-TIGHT ONLY**. Be sure all elements are properly seated and clamped.
8. Inspect the filter cover gasket for damage and replace if necessary. Close the filter cover and tighten the clamping bolts evenly.
9. Replace and tighten vent plug.

FUEL INJECTOR NOZZLE

Removal

1. Remove the cylinder-head cover.
2. Clean the high-pressure line with a stiff-bristle brush and fuel oil before disconnecting.
3. Remove the high-pressure line between the pump and nozzle. Cover all openings with threaded or plastic caps.
4. Remove the two nuts which secure the nozzle clamp.
5. Remove the fuel injector nozzle from the cylinder head. Use the knocker, Part 147X1856, to facilitate removal, Fig. IX-57.

FIG. IX-53, E-25408

FIG. IX-54, E-25436

FIG. IX-55, E-25437

FIG. IX-56, E-25438

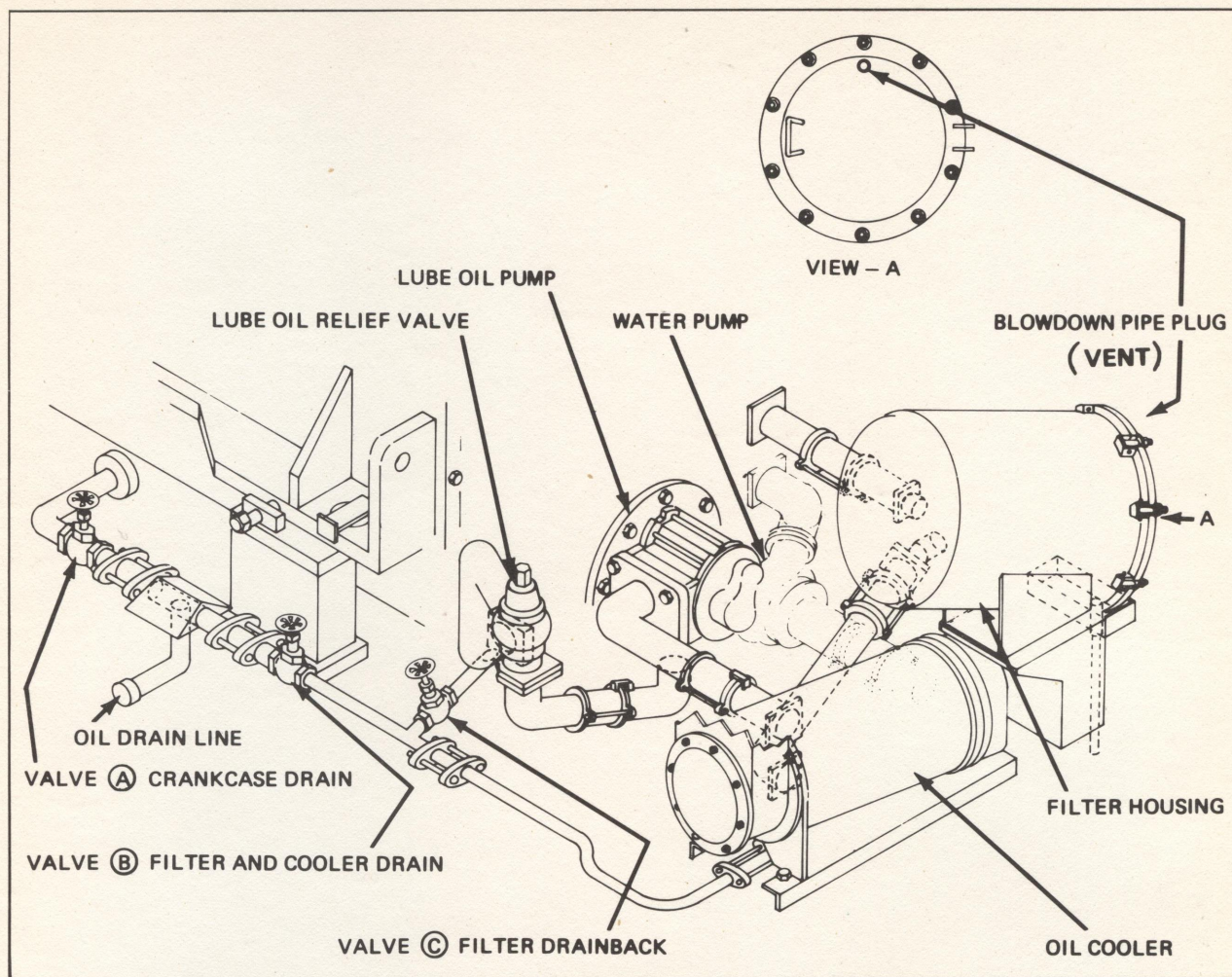


FIG. IX-56. LUBE-OIL PIPING DIAGRAM.

CAUTION: Handle the fuel injector nozzle with care and take measures to prevent dirt from entering the nozzle. DO NOT BUMP THE TIP. Place protective plastic caps or plugs over connections and put a protective cover over the tip end. RETURN INJECTORS FOR REPAIR PROTECTED IN THE SAME MANNER AS NEW NOZZLES ARE RECEIVED.

Installation

1. If difficulty is encountered in removing a fuel injector nozzle from the cylinder, the nozzle recess in the cylinder head is probably encumbered with carbon, scale, etc. This must be cleaned before installing a new nozzle. This may be done in the following manner:

- a. Use a 1-in. diameter cup wire brush (0.020-in. diameter wire) on a 15-in. extension, driven by a portable power drill.
 - b. The entire length of the recess should be cleaned, but the seat is of particular importance.
 - c. If it is necessary to clean the recess with the cylinder on the engine, be sure the valves are closed and the cylinder-head cover is in place.
 - d. Apply air pressure through the compression-release hole to blow dirt up through the recess, instead of allowing it to fall down on the face fit and into the cylinder.
2. Place a new copper gasket on the small end of the nozzle. A small amount of grease can be used to hold the gasket in place.

3. Connect the high-pressure line between the pump and injector. Tighten both nuts with 140-150 lb.-ft. of torque, using the special wrench, GE Part 147X1595-1, Fig. IX-58.
4. Install the adjustable link between the pump rack and the bellcrank. Secure with the fulcrum nut torqued to 30-35 lb.-ft.
5. Check the pump rack setting and adjust if required. Refer to ADJUSTMENTS section.
6. Check the pump timing. Refer to ADJUSTMENTS section.
7. Replace the cylinder-head cover.

WATER PUMP

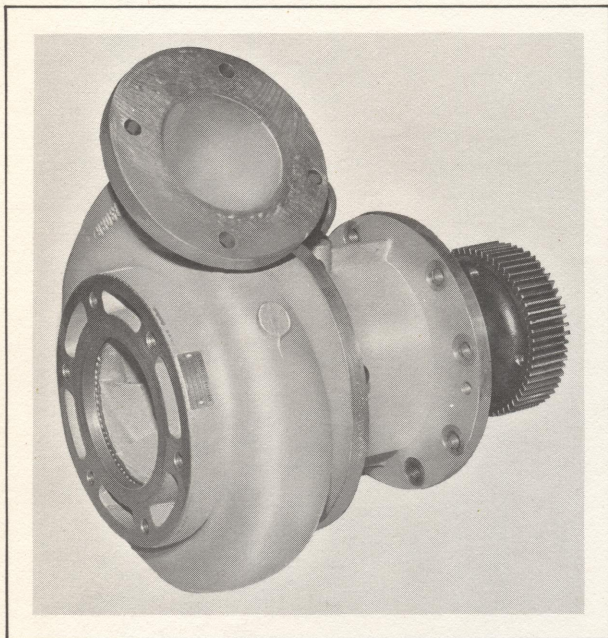


FIG. IX-62. WATER PUMP.

Removal

1. Drain the lube oil from the forward-end cover. See Section X, LUBRICATING-OIL SYSTEM.
2. Drain the water system. See Section X, COOLING WATER SYSTEM.
3. Remove the pipe flange bolts, loosen the inlet pipe Dresser coupling, and slide the coupling on the pipe to clear the joint.
4. Remove the pump inlet and discharge pipes.

5. Mount a suitable lifting hoist over the pump, and attach it to the pump lifting eyebolt.
6. Remove the pump mounting bolts, install the jack bolts in threaded holes in the flange, and evenly jack the pump from its rabbet fit.

Installation

NOTE: *If the gear is being replaced, thoroughly clean the tapered fits. Make sure the large flat washer between the drive gear nut and the drive gear is assembled with the chamfer toward the gear. Torque the nut to 200-220 lb.-ft. and install a new cotter pin.*

1. Install the pump, using a new gasket. Properly align the drive-gear teeth and the pump register fit. Install the bolts finger-tight.

CAUTION: *Care must be taken to insure the pipe flange alignment is correct; otherwise, the pump casing may be distorted and broken.*

2. Assemble the cast discharge pipe, using new gaskets. Assemble discharge elbow and pump mounting bolts finger-tight first; then snug all bolts lightly, and finally tighten securely.
3. Reassemble the inlet pipe using new gaskets.
4. Before barring-over the engine, fill the water system to the proper level and add treatment.
5. Add lubricating oil to the crankcase to the proper level.

NOTE: *A small amount of water seal leakage may be noted on a newly installed pump. However, after a short period of operation, the water seal should become seated, thus stopping all leakage.*

LUBRICATING-OIL PUMP

Removal

1. Drain the oil from the crankcase, the forward-end cover, the oil cooler and the filter. See Section X, LUBRICATING-OIL SYSTEM.
2. Disconnect the discharge pipe at the pump.
3. Install a 3/4 in.-10 lifting eyebolt into the pump casing and attach a crane hook to support the pump weight. Lift and remove the pump from the engine.

FIG. IX-62, E-20897

FIG. IX-63, E-9927

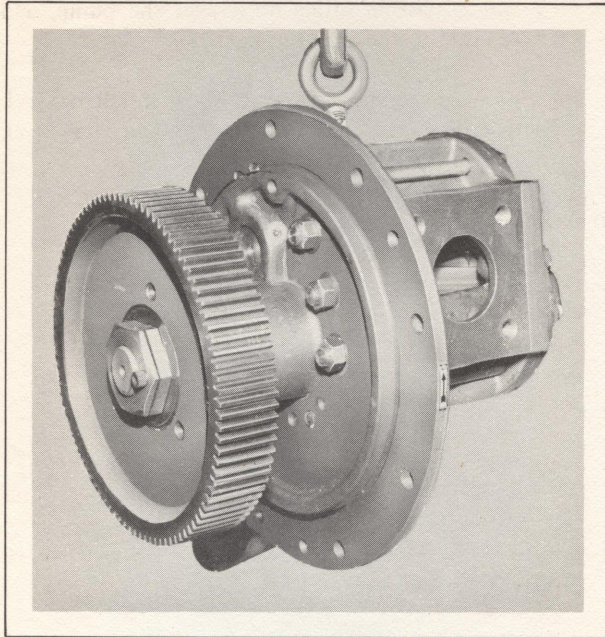


FIG. IX-63. LUBRICATING-OIL PUMP.

Installation

NOTE: If the drive gear is being replaced, thoroughly clean the tapered fits and install a key. Torque the large drive gear nut to 375-400 lb.-ft. Tighten the lock screw on the nut to 30-36 lb.-ft.

1. Clean the gasket surfaces, and use new gaskets where needed.
2. Insert a 3/4 in.-10 lifting eyebolt into the oil-pump housing. Position the pump on the engine with an overhead crane.
3. Hand-tighten the pump and discharge pipe bolts to ensure the compression pipe coupling is aligned.
4. When the pipes are aligned, tighten the mounting bolts to 90 lb.-ft. (122 N·m) of torque if bolts are dry; to 70 lb.-ft. (95 N·m) of torque if bolts are lubricated.

Clean the oil drain valves and fill the crankcase to the proper level before starting the engine. After starting the engine, check the lube-oil pump for overheating or unusual noises.

POWER ASSEMBLY REMOVAL

A power assembly consists of a complete cylinder, piston, piston rings, connecting rod and bearings.

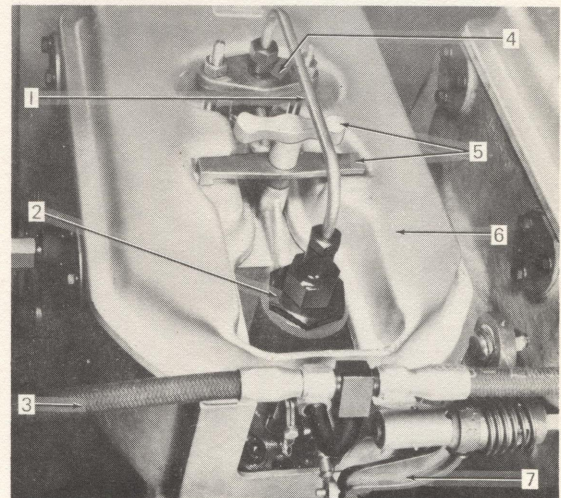
Cylinders may be removed either with or without their respective pistons and connecting rods, depending on the nature of work to be performed. Cooling water must be drained before cylinder removal. Lube oil should be drained if extensive work is to be performed, to guard against contamination of the oil.

NOTE: When removing cylinders only, install new piston rings. See Piston Rings section.

To remove a cylinder, proceed as follows:

1. Disconnect and remove the following parts from the cylinder:
 - a. Cylinder cover.
 - b. Fuel-header lines at flexible hose couplings. Cap the lines and the pump inlet connection to keep the dirt out.
 - c. Water inlet and discharge headers. Loosen the compression couplings and remove the bolts from the flanges. Remove the upper water connection and compression elbow.

FIG. IX-64, E-9985A



REF.	DESCRIPTION
1	HIGH-PRESSURE LINE
2	FUEL-INJECTION PUMP
3	FUEL-HEADER LINE
4	FUEL-INJECTION NOZZLE HOLD-DOWN CLAMP
5	CLAMP BAR AND THREADED TEE-HANDLE
6	CYLINDER COVER
7	PUMP-RACK LINKAGE

FIG. IX-64. UPPER-CYLINDER DETAILS.

Inserting Push Rods

To obtain sufficient clearance when installing push rods, each valve crosshead roller must be off the high portion of its cam. With the rollers on the base circle of the cams, proceed as follows:

1. Insert the vertical push rods into their sockets in the crossheads; then, install the short crossover push rod.
2. Rotate the rocker arms, using rocker arm depressor, Part 147X1040-1, Fig. IX-68, until the push rods can be inserted into their respective rocker-arm sockets.

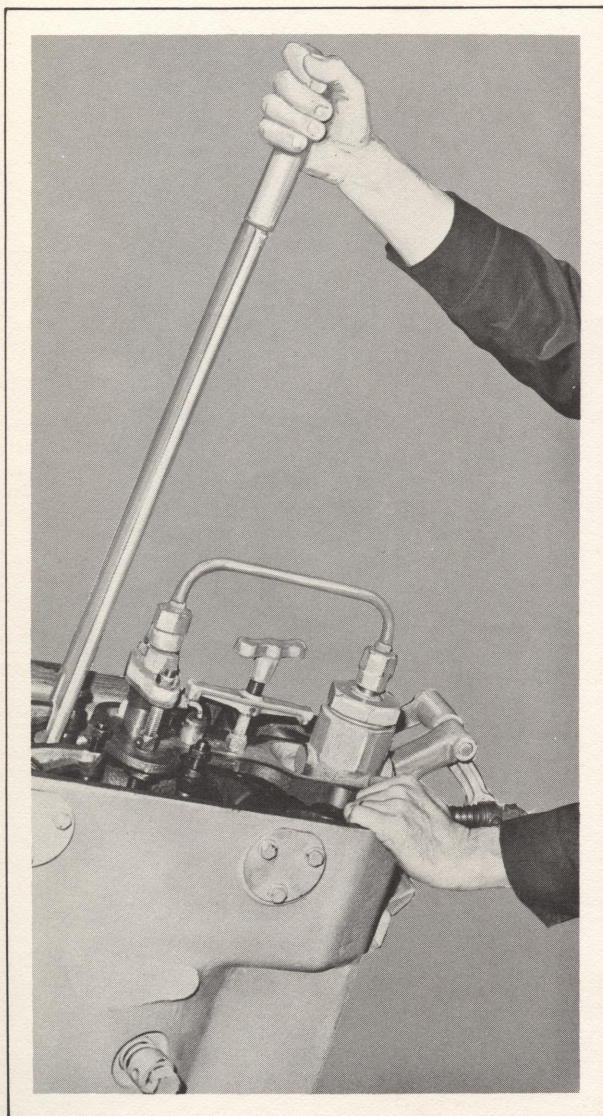


FIG. IX-68. DEPRESSING VALVE SPRING WITH ROCKER ARM DEPRESSOR TOOL.

Adjusting Tappet Clearance and Pump Timing

Valve tappet clearance and fuel-pump timing can both be done at the same positioning of the piston in the cylinder. Fuel injection pump racks must also be set. See Fuel Pump Rack Setting, Fuel Pump Timing and Valve Tappet Clearance Setting under ADJUSTMENTS section.

PISTON RINGS

Piston Ring Wear

Ring wear is the result of many factors, some of which are as follows:

1. Type of service and terrain
2. Effectiveness of engine air filter maintenance
3. Type of fuel and lube oil used
4. Degree of lube-oil control
5. General quality of engine maintenance.

Because of these factors, it is impossible to coordinate the rate of ring wear with engine operating time or locomotive miles traveled under all conditions. Therefore, for best economy, the rate of ring wear and thus the ring renewal periods can be determined best after a period of service under actual operating conditions.

For most efficient operation and best economy, it is recommended that piston rings, removed from an engine for any reason, be discarded and new rings applied. Any sticking rings or rings which show scuffing, burning or other abnormal conditions **MUST** be renewed regardless of wear.

Also, any time that a cylinder is changed out, piston rings should be renewed.

CAUTION: *Cylinder scoring and severe shortening of ring and liner life will result if chrome rings are used with chrome liners or iron rings with Tufftrided liners. Refer to your Renewal Parts Catalog for the proper ring and liner combinations. See Fig. IX-70.*

Rings may be renewed after cylinders are taken off, without removing the pistons from the engine. When on or near top dead center, the pistons extend above the engine main frame. To renew rings, proceed as follows:

1. After the old rings are removed, clean the ring grooves to assure full ring side clearance. The ring scraper tool, Part 147X1098, Fig. IX-69, should be used to clean carbon from the ring grooves.

CAUTION: *Care must be exercised when removing carbon so the ring grooves do not become damaged.*

FIG. IX-69, E-19813

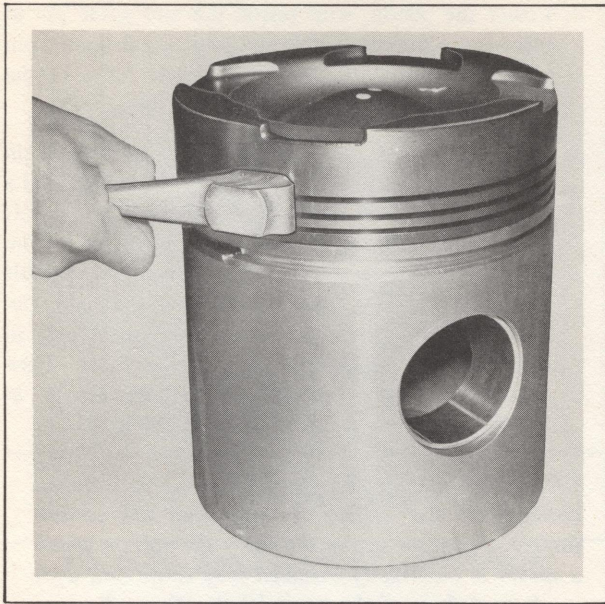


FIG. IX-69. CLEANING PISTON RING GROOVE WITH SCRAPER, PART 147X1098.

Insure foreign material does not enter the crankcase. Dirt and cleaning materials from groove cleaning can cause serious damage to bearings and other internal engine parts.

2. When installing rings, always use the ring expander tool, Part 147X1099, to prevent permanent distortion of the rings.
3. Install the oil-control ring first. Assemble the expander spring in the ring groove. Then, place the ring, SCRAPING EDGES DOWN, over the expander

FIG. IX-71, E-19823

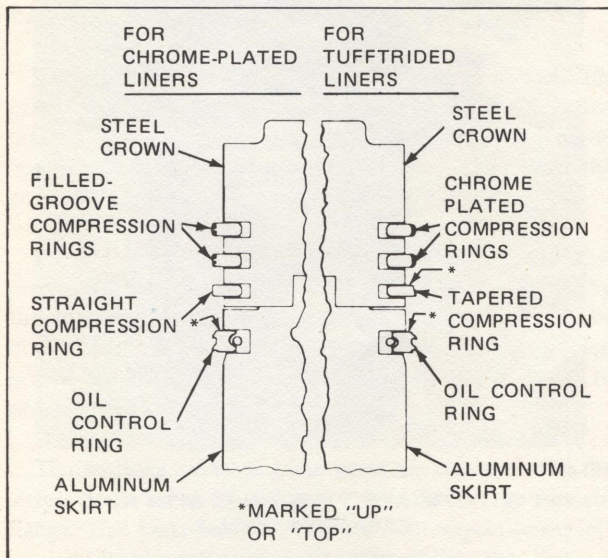


FIG. IX-70. PISTON RING ARRANGEMENTS.



FIG. IX-71. PISTON SUPPORT BAR UNDER PISTON.

spring, and in its groove. Position the oil-ring end gap 180 degrees from the expander spring joint.

4. Install the compression rings as indicated by their markings. Rings not marked may be installed with either side up.
5. Assure all rings fit freely in their grooves at all positions around the piston. Then stagger the end gaps of adjacent rings approximately 90 degrees with no two in line.

PISTON

Removal

To replace a piston it is necessary to remove the cylinder assembly first. See Power Assembly Removal section. The cylinder bore should be inspected for scoring or excessive wear, particularly in the ring reversal area, to determine if it is suitable for reuse with a new piston.

Proceed as follows to replace a piston:

1. With the piston near top dead center, lift the cylinder assembly partially off the piston and apply a piston support bar, Part 147X1090, under the piston. Rest the piston support bar on the main frame and bar the engine back until the piston rests on the cradle of the piston support bar, Fig. IX-71.
2. Lift the cylinder completely off the engine.

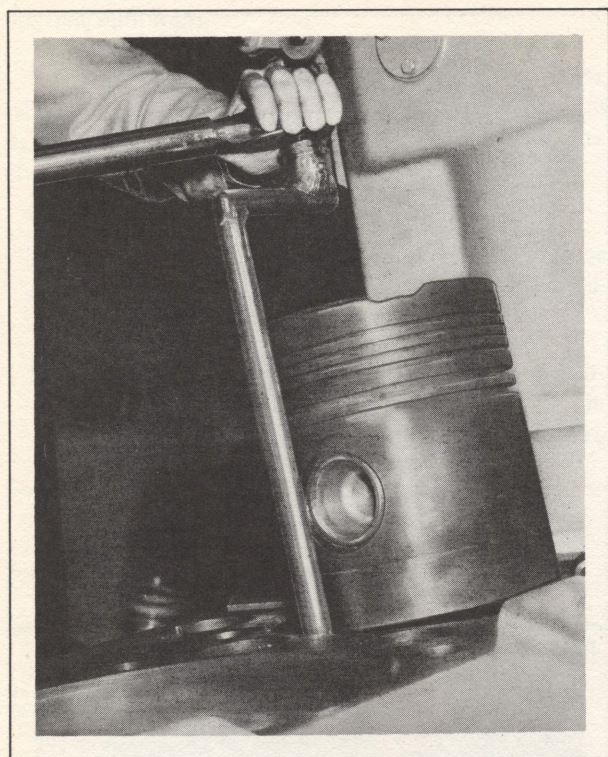


FIG. IX-72. LOOSENING PISTON PIN BOLTS.

3. Using a piston pin bolt wrench, Part 147X1841, and a piston pin bolt socket, Part 147X1511, use a 3/4-in. drive ratchet to loosen the piston pin bolts, Fig. IX-72.
4. Carefully remove the piston. Save the piston pin for reuse in a new piston.

Installation

1. Coat the piston pin liberally with clean lube oil and install it. Install a piston pin guide pin into one of the threaded holes in the piston pin. A guide pin may be purchased as Part 147X1326, or it may be made from a piston pin bolt with the head cut off and the end bullet-nosed, Fig. IX-73.

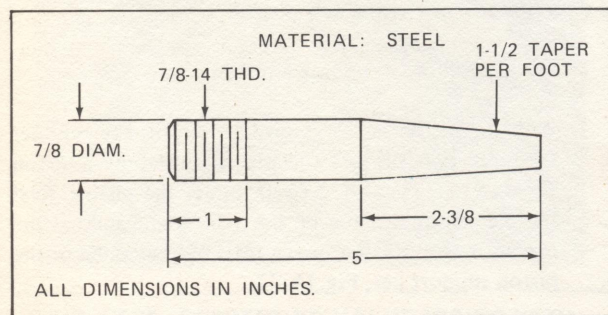


FIG. IX-73. PISTON PIN GUIDE PIN.

2. Lower the piston, with piston pin and guide pin in place, onto the connecting rod, allowing the guide pin to enter one of the piston pin bolt holes in the connecting rod.
3. Coat the threads and washer faces of the piston pin bolts with Molykote G-n*, Part 147X1143-1. Install a piston pin bolt and spacer in the other piston pin bolt hole and finger tighten. Remove the guide pin from the first bolt hole and install the remaining pin bolt and spacer. Using a torque wrench and the piston pin bolt wrench, tighten the piston pin bolts evenly in increments of 100-125 lb.-ft. to 400 lb.-ft. Then loosen the bolts and retighten them evenly in increments to a final torque value of 250 lb.-ft.

CAUTION: Unless the pin bolt spacer is installed correctly — flat surface to bolt head and convex surface to concave seat in the rod — the bolt on which a spacer is incorrectly installed may come out, with resultant failure of the second bolt. This will cause serious damage to the engine main frame and other components.

4. Install new piston rings, using a Part 147X1099 ring expander, Fig. IX-74. Stagger the ring end gaps of adjacent rings approximately 90 degrees apart with no two in line. Refer to Piston Rings section.
5. Support the piston with the piston support bar and coat the piston with clean lube oil. Apply the ring compressor, Part 147X1089, Fig. IX-75.



FIG. IX-74. APPLYING RINGS WITH RING EXPANDER TOOL.

*Product of Dow Corning Corp.

FIG. IX-72, E-20357

FIG. IX-73, E-25602

FIG. IX-74, E-19817

FIG. IX-75, E-19819



FIG. IX-75. APPLYING RING COMPRESSOR.

6. Lower the cylinder assembly onto the piston until the rings enter the liner. Remove the ring compressor and piston support bar and lower the cylinder into place.
7. Secure the cylinder assembly and reassemble all components. Refer to Power Assembly Installation section.

CAUTION: Cylinder scoring and severe shortening of ring and liner life will result if chrome rings are used with chrome liners or iron rings with Tufftrided liners. Refer to your Renewal Parts Catalog for the proper ring and liner combinations. See Fig. IX-76.

CAMSHAFT SECTIONS AND BEARINGS

Two sectionalized camshafts, one mounted in each side of the engine frame, are driven by gearing directly from the crankshaft. Both camshafts rotate in the same direction, opposite to the crankshaft rotation, and at one-half the crankshaft speed.

Each sectionalized camshaft is made up of individual precision-machined sections which are fastened together by threaded dowels and nuts. See Figs. IX-77 and IX-80. The intake, fuel, and exhaust cams are integral parts of each hollow section. The journal and cam sections are treated to provide hardened wear surfaces.

The sections containing the cams are stamped with the letters L (left) or R (right) on the edge of the forward flange. This identifies their location with respect to the left or right banks of the engine. The edge of the other flange is stamped with numbers (see Table IX-IV) which are used to

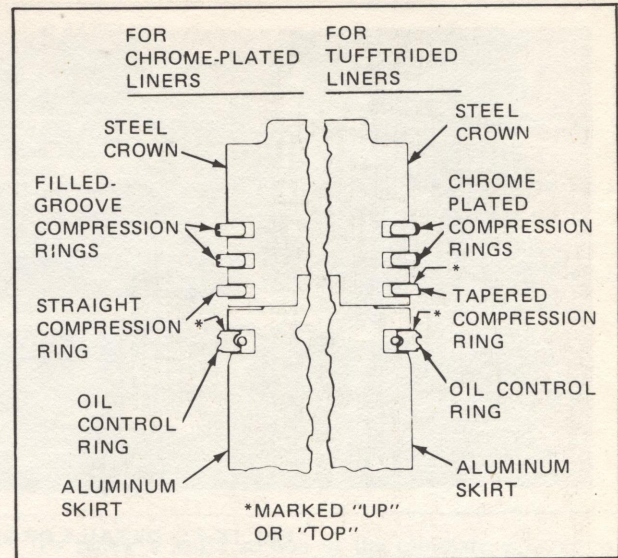


FIG. IX-76. PISTON RING ARRANGEMENTS.

TABLE IX-IV, CAMSHAFT MARKINGS

Cylinder Location (Right or Left Bank)	Engine Model		
	16 Cyl.	12 Cyl.	8 Cyl.
8	8		
7	$\frac{3}{7}$		
6	6	6	
5	$\frac{1}{5}$	$\frac{4}{5}$	
4	4	$\frac{4}{5}$	4
3	$\frac{3}{7}$	3	3
2	2	$\frac{1}{2}$	2
1	$\frac{1}{5}$	$\frac{1}{2}$	1

properly index the section's position in the shaft with respect to the corresponding cylinder. These sections are interchangeable within their respective camshafts but, because of the reversal between the inlet and exhaust cams, they are not interchangeable between the left and right bank camshafts.

A stub section is located at the drive end of each camshaft. This is a universal piece which may be assembled, by proper indexing, to either the left or right bank camshaft.

When assembling a complete camshaft or replacing a section of either camshaft, the sections must be properly indexed with respect to their location in the shaft. Beginning at the drive end of the shaft, align the numeral of

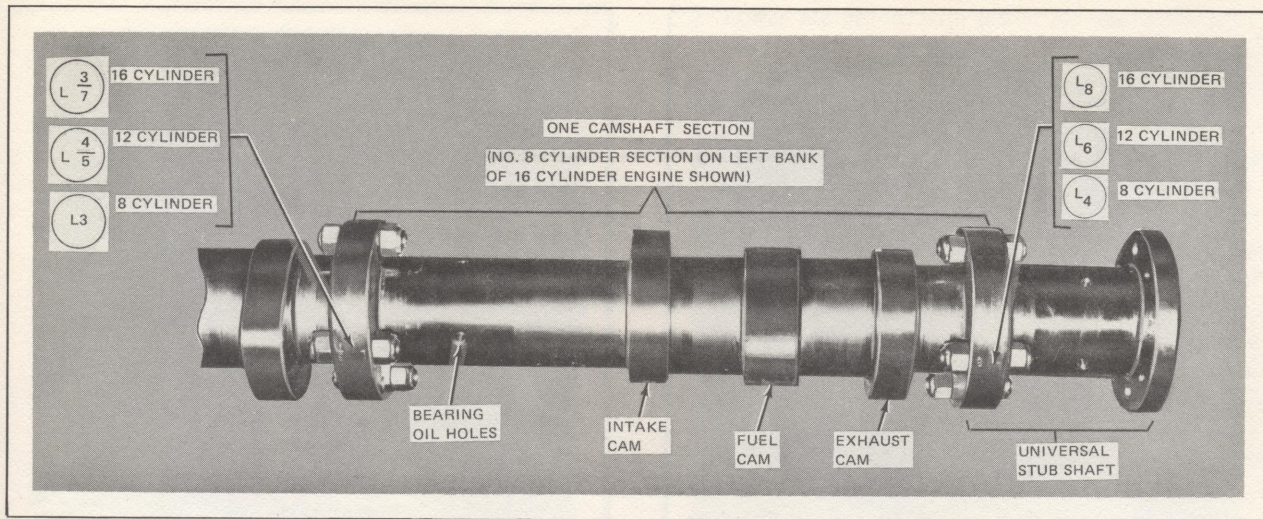


FIG. IX-77. DETAILS OF SECTIONALIZED CAMSHAFT.

the last cylinder (8, 6 or 4) with the proper bank letter (L or R) on the stub section and bolt them together. Rotate the shaft so the bank letter on this section is plainly visible, and align the numeral for the next cylinder (e.g., 7 marked $\frac{3}{7}$ shown in Fig. IX-77) next to the bank letter. Bolt this section to the previous one and proceed to the next section in a like manner, until the free end of the engine is reached. See Table IX-IV for proper numerical markings.

CAUTION: Camshaft sections are not interchangeable between the right and left bank of the same engine nor are sections interchangeable between engines having different numbers of cylinders. For example, a section from a 12-cylinder engine cannot be used in either an 8-cylinder or a 16-cylinder engine.

A cover bolted over the end of the free-end camshaft section closes the end of the central oil passage in the shaft.

Support Bearings (Fig. IX-78)

Removable aluminum-alloy split bearings support each shaft within the engine frame in the line-bored bearing seats. The bearings are held in place by bolts extending from outside the engine frame into tapped holes in the bearings. The tapped holes are reinforced by helical steel thread inserts.

The two bearing halves are aligned by hollow steel dowels and are held together by bolts threaded into the steel thread inserts. The two bearing halves are match-marked with numerals and should always be installed as a set. The bearings may be removed from the engine for inspection or replacement without disturbing the camshaft.

Thrust Bearings

A thrust bearing assembly, located next to the drive gear on each camshaft, controls the longitudinal shaft movement. A steel thrust ring, positioned by a dowel, is located between the camshaft flange and the drive gear. A semi-circular, grooved bearing is bolted to the engine frame and fits over the thrust ring to restrict the longitudinal travel, Fig. IX-79.

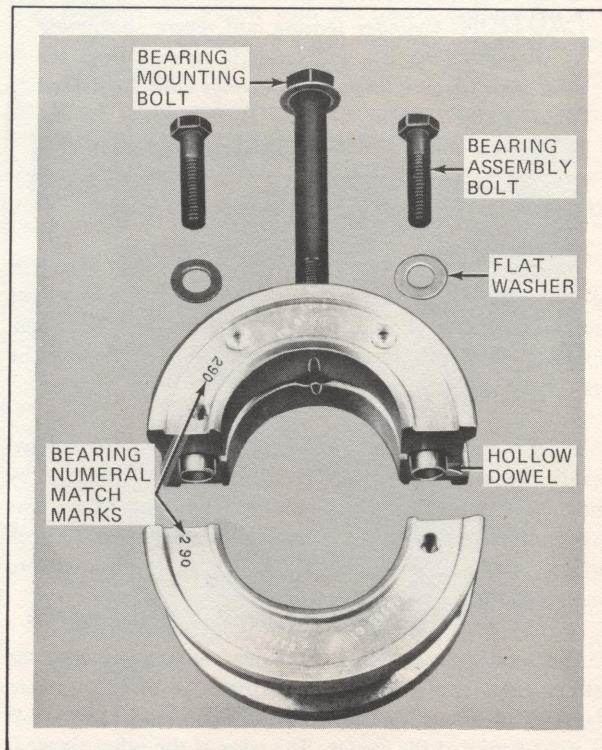


FIG. IX-78. CAMSHAFT BEARING ASSEMBLY.

FIG. IX-77, E-16168A

FIG. IX-78, E-13239

FIG. IX-79, E-13320

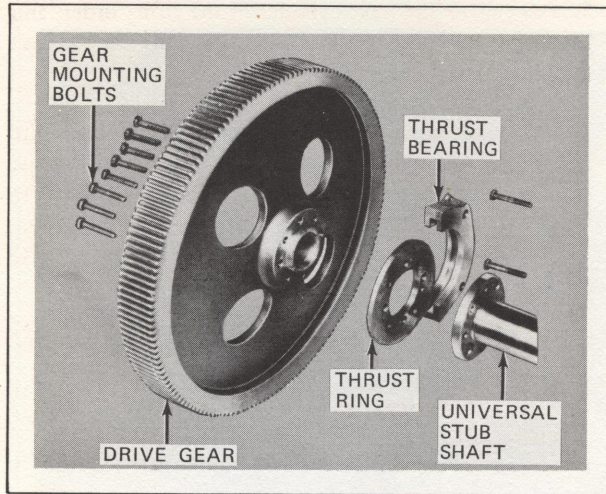


FIG. IX-79. CAMSHAFT DRIVE AND THRUST BEARING ASSEMBLY.

By properly positioning the drive gears, the thrust bearing bolts may be removed through holes in the gear webs without removing the drive gears.

Drive Gears

The drive gears and thrust rings are bolted together and to the camshaft drive flange. An indexing dowel in the hub of each gear correctly positions the timing dots on the gear with respect to its camshaft. The timing dots are located on the side of the gear rim facing the generator-end of the engine.

Removing Camshaft Bearings

To inspect or renew a camshaft bearing, proceed as follows:

1. Remove the crankcase inspection cover and the bearing mounting bolt which extends through the side of the engine frame.

If more than one bearing is to be removed, place wooden blocks under the camshaft to support it after the first bearing is removed. If all the bearings are being removed, remove the center bearing first, and work toward both ends.

2. Carefully tap the bearing from its bore with a soft hammer.
3. Remove the bearing assembly bolts, then separate the halves and remove the bearing from the shaft.

CAUTION: Do not pry bearing halves apart. Instead, while removing the bearing assembly bolts and while the last few threads are still engaged, lightly tap each bolt head to separate the bearing halves.

To install a bearing, reverse the above procedure. Use a new stat-o-seal washer with the bearing mounting bolt and lubricate both sides of the stat-o-seal with Lubriplate. Torque the bearing assembly bolts to 35-40 lb.-ft. Torque the bearing mounting bolts to 40-45 lb.-ft.

NOTE: A coat of clean engine crankcase oil on the bearing and its bore will make bearing installation easier.

Removing Camshafts

To renew a single section of the camshaft, proceed as follows:

1. Compress the valve springs and release the valve push-rods from their sockets on ALL cylinders in the bank of the engine where a camshaft section is to be removed. Use rocker arm depressor, Part 147X1040-1.
2. Lift the valve and fuel crossheads (on all cylinders in the bank), and lock them up using a locking pin inserted through the hole in the crosshead guide. To raise the fuel crosshead against the pump spring pressure, force a hardwood or fiber wedge between the roller and cam.
3. Bar-over the engine until the index marks on the flanges of cam section to be removed are visible in the crankcase inspection opening.
4. Remove the mounting bolts from the two cam bearings adjacent to the section to be replaced. Then, carefully push the bearings out of their bores in the frame.
5. Loosen the bearing assembly bolts and separate the bearing halves. Use care not to damage the bearing. Bearing halves can be separated by not completely removing the bolts, then tapping lightly on the head of the bolts until the bearing has separated from the hollow dowel.
6. Remove the four nuts from the cam section flange toward the drive end of the camshaft. Using a pry bar placed against a cam and the engine frame, separate the sections. Push the free end of the shaft towards the free end of the engine until the opening between the flanges is approximately equal to the width of a cam roller.

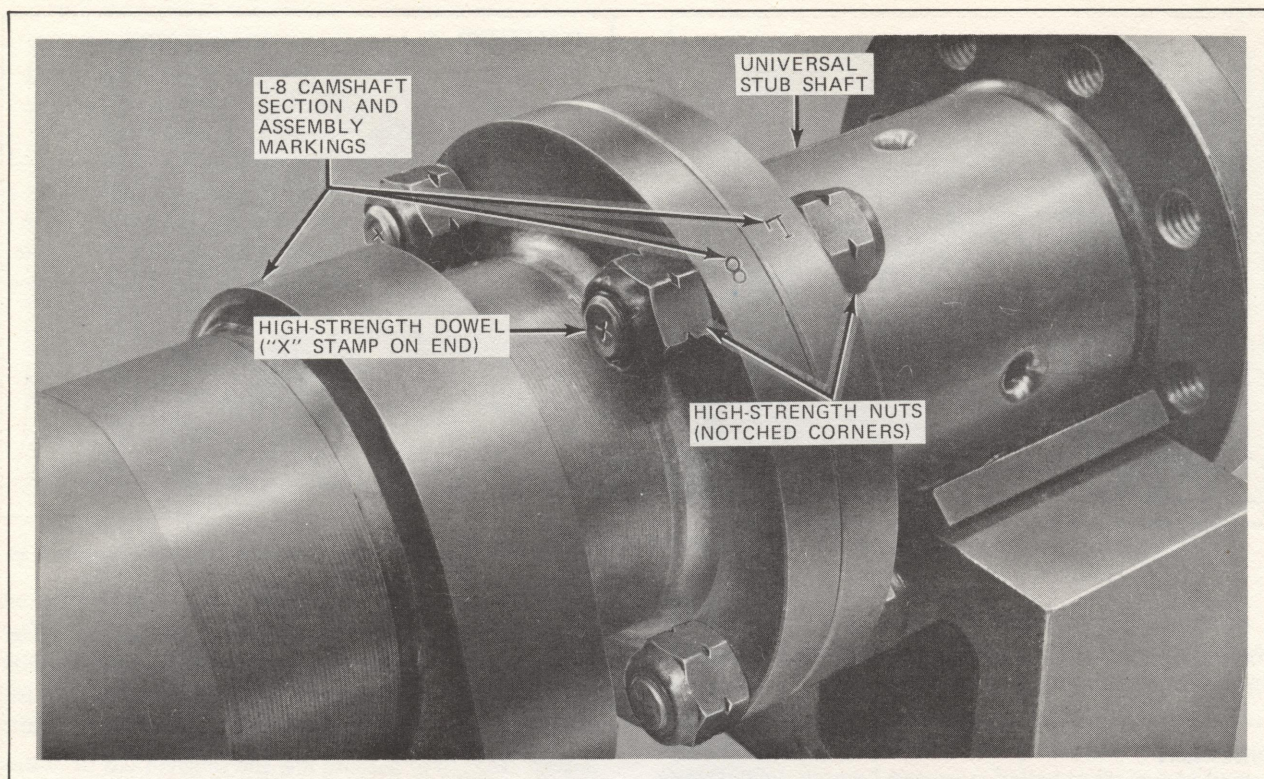


FIG. IX-80, E-25603

FIG. IX-80. CAMSHAFT ASSEMBLY WITH NEW STYLE HIGHER STRENGTH DOWELS AND NUTS.

7. Remove the remaining four nuts which attach the cam section, and remove the section through the inspection opening.
8. Install the new section in the reverse of the above sequence. Observe the index markings as previously described. Use special care to keep flanges and pilots clean and free of burrs. Tighten camshaft dowel nuts to 80-90 lb.-ft. of torque. Older style dowels and nuts must be assembled dry. Current production dowels and nuts should be lubricated on the dowel threads and the nut faces with Molykote G-n. Torque to the same value. See Fig. IX-80 for identifying newer style dowels and nuts.
9. After replacing a camshaft or any section:
 - a. Remove the lock pins from all crossheads.
 - b. Replace the push rods.
 - c. Reset all the valve clearances.
 - d. Check the timing on all fuel pumps.

CONNECTING ROD

Removal

Since the cylinder assembly must be removed before a master or articulated rod can be replaced, it is

recommended that the cylinder, piston and rod be removed as a complete power assembly. Refer to Power Assembly Removal section for the general procedure.

To remove a rod, proceed as follows:

1. Removing either rod requires the articulated rod to be disconnected. Remove the articulated rod pin bolts, using a Part 147X1458-1 wrench and a Part 147X1823 torque wrench.
2. Install an art rod pin retainer to hold the art rod pin in place until the rod is reassembled, Fig. IX-82.
3. If the master connecting rod is to be removed, loosen the connecting rod cap bolts and back them off, leaving several threads engaged. Use the ratcheting torque wrench, Part 147X1823 and 1-1/8 in. socket, Part 147X1866. See Fig. IX-83.
4. Tap the cap sideways with a heavy brass bar. The cap will drop onto the bolt heads. Remove the bolts and the cap.
5. Remove the power assembly as described in Power Assembly Removal section. If the art rod is not being removed, bar the engine so that the art rod is in its topmost position and block or otherwise secure it in that position.

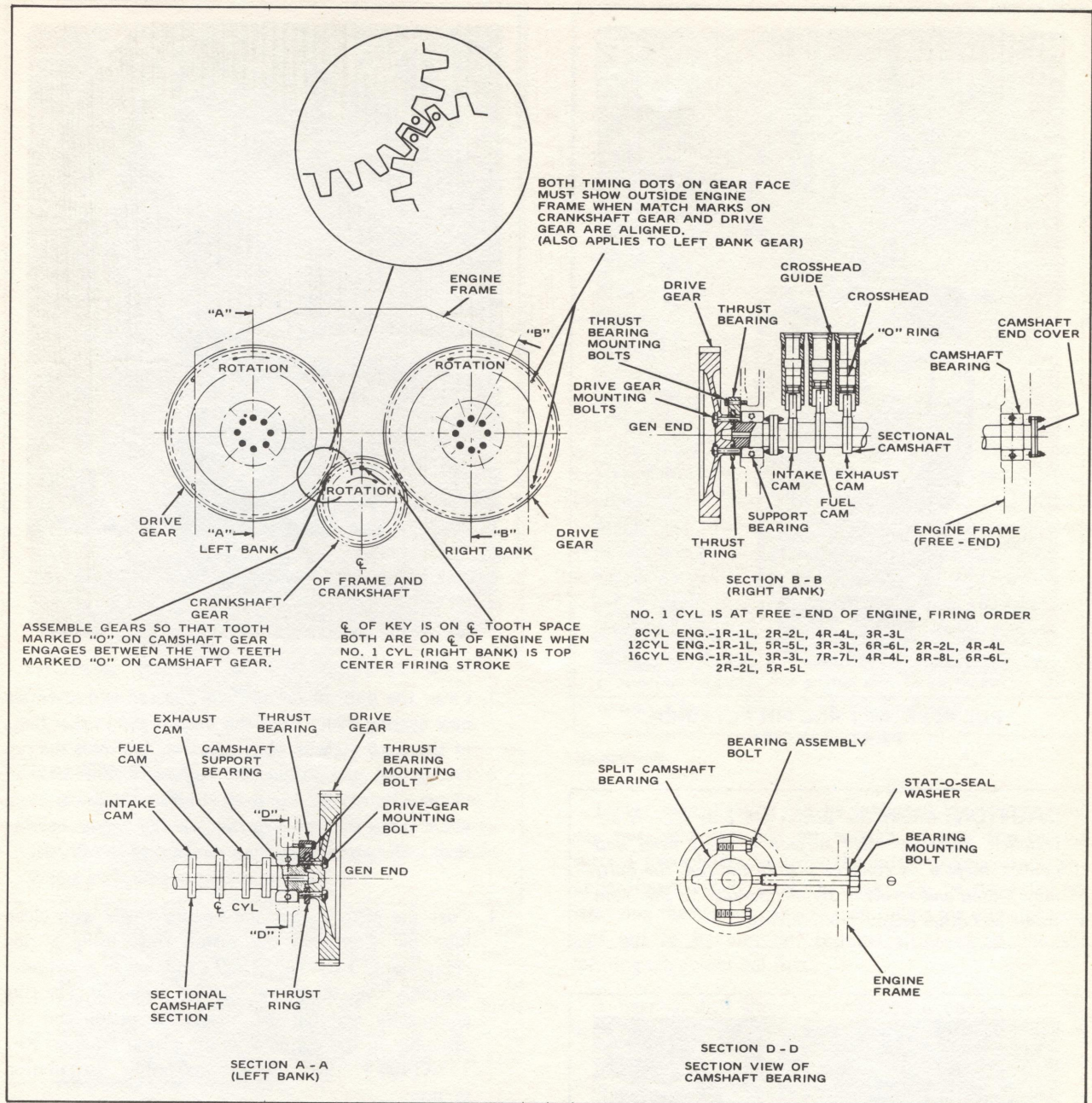


FIG. IX-81. CAMSHAFT DRIVE AND ASSEMBLY.

CAUTION: Protect the rod journal with a protective pad, Part 147X1827, while the journal is exposed.

6. Separate the piston and rod assembly from the cylinder assembly.
7. With the rod and piston secured in a rod holding fixture, Part 147X1651, remove the connecting rod from the piston pin. Remove piston pin bolts with wrench, Part 147X1499.

Installation

1. Lubricate the threads and washer faces of the piston pin bolts with Molykote G-n. With the rod secured in a rod holding fixture, Part 147X1651, assemble the piston, with piston pin, to the rod with bolts and spacers. Tighten the piston pin bolts evenly in increments of 100-125 lb.-ft. to 400 lb.-ft. of torque. Then loosen the bolts and retighten to a final torque value of 250 lb.-ft.

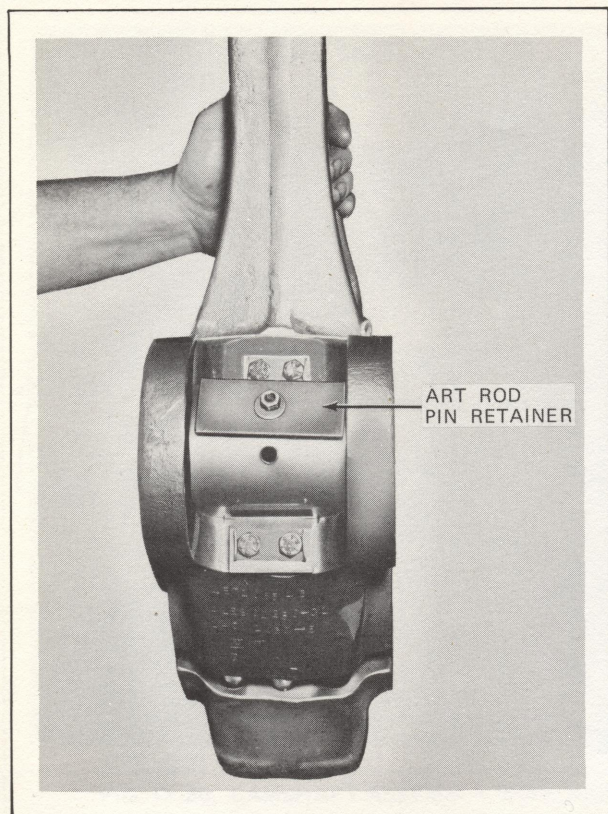


FIG. IX-82. ART ROD PIN RETAINER, PART 147X1474.

CAUTION: Unless the piston pin bolt spacers are installed correctly; flat surface to bolt head and convex surface to concave seat in the rod, the bolts may loosen and result in serious damage to the main frame and other engine components.

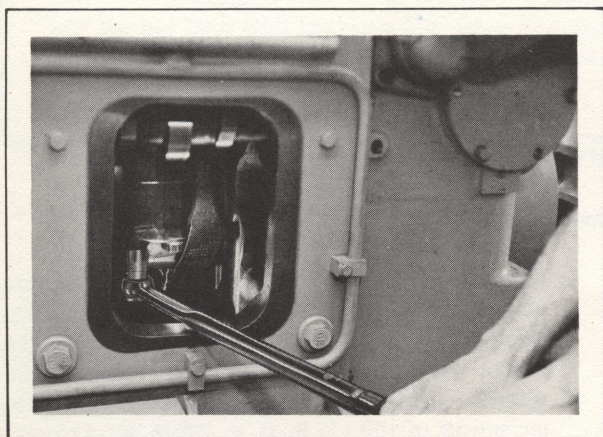


FIG. IX-83. TIGHTENING CONNECTING ROD CAP BOLTS.

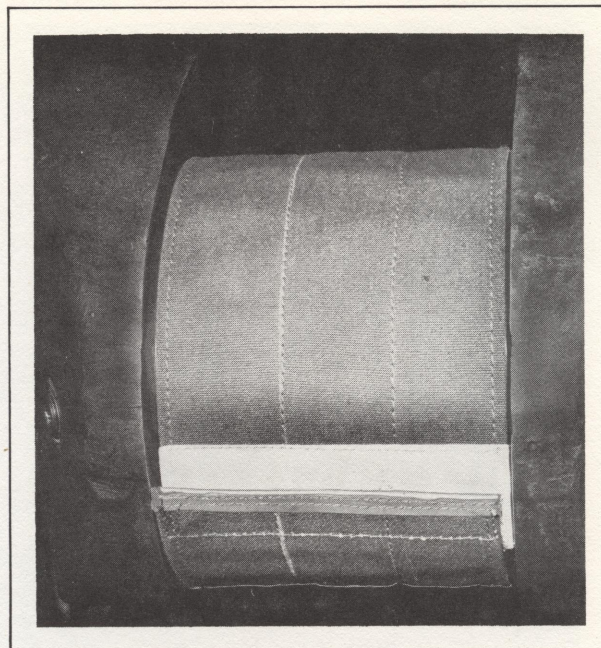


FIG. IX-84. PROTECTIVE PAD ON ROD JOURNAL.

2. Renew the piston rings — see Piston Rings section.
3. Clean the bore of the rod and rod cap and assemble new bearing shells. Coat the threads and washer faces of the cap bolts with Molykote G-n. Assemble the cap to the rod and torque the cap bolts alternately in increments of 100-125 lb.-ft. to 400-420 lb.-ft. Then disassemble the rod cap. Secure the upper bearing shell with two bearing retainers, Part 147X1492-1.
4. Coat the piston, rings and bearing shells with clean lube oil. Compress the piston rings using a ring compressor, Part 147X1089, and lower a cylinder assembly over the piston and rod assembly. The ring compressor will fall off. Secure the piston and rod assembly in the cylinder with a piston retainer, Part 147X1406-1. See Power Assembly Installation section.
5. Lift the power assembly and lower it into position on the rod journal after removing the protective pad. If installing an assembly with an art rod, remove the art rod pin retainer and thread an art rod guide pin, Part 147X1122, into one of the art rod pin bolt holes. Lower the art rod onto the art rod pin, Fig. IX-85.
6. Coat the art rod pin bolts and/or the master rod cap bolts with Molykote G-n on the threads and washer faces.

FIG. IX-82, E-20352

FIG. IX-83, E-22472

FIG. IX-84, E-20361

FIG. IX-85, E-20353

FIG. IX-86, E-25604

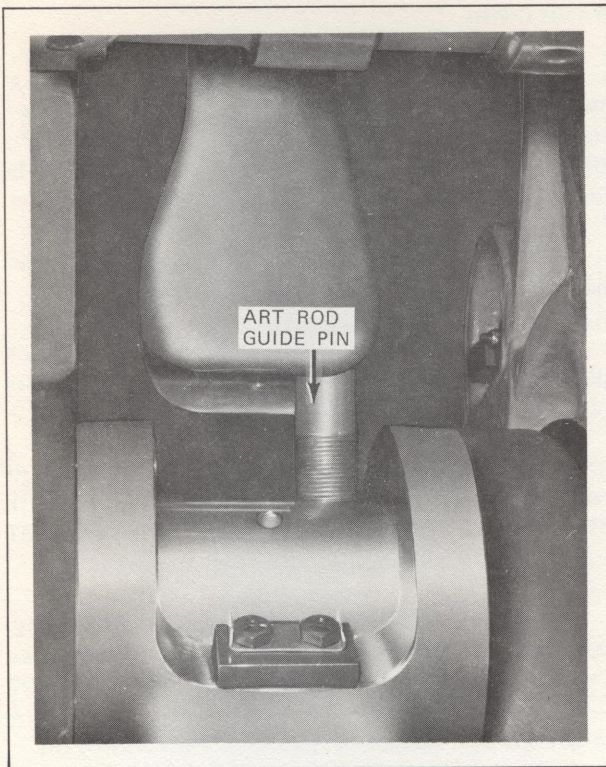


FIG. IX-85. INSTALLING ART ROD USING GUIDE PIN, PART 147X1122.

CAUTION: Unless the art rod pin bolt spacer is installed correctly — flat surface to bolt head and convex surface to concave seat in the rod — the bolts may loosen and result in serious damage to the main frame and other engine components.

7. After removing the two bearing retainers, assemble the rod cap. Tighten the master rod cap bolts alternately in increments of 100-125 lb.-ft. to 400-425 lb.-ft. Tighten the art rod pin bolts alternately in the same increments to 450 lb.-ft. Loosen the art rod pin bolts and retighten to a final torque value of 375 lb.-ft.

MAIN BEARINGS AND THRUST COLLARS

Semicircular bearing shells support the crankshaft within the engine. They are secured by bearing caps which are bolted in place.

The bearing shells are precision type and are replaceable without machining or scraping. Each bearing shell has a steel back which supports two or more layers of carefully formulated bearing material.

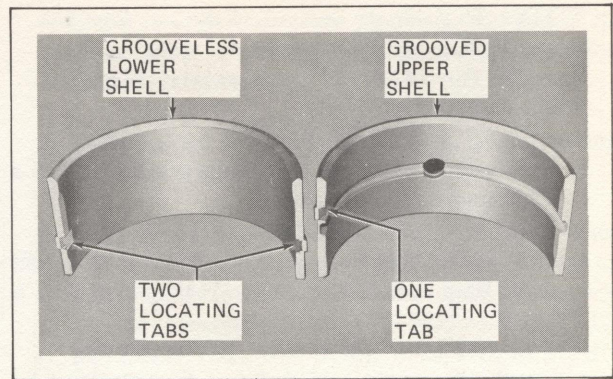


FIG. IX-86. UPPER AND LOWER MAIN BEARING SHELLS.

New Series locomotive engines are equipped with grooveless main bearing shells in the lower position and a grooved main bearing shell in the upper position. Each bearing half with oil groove contains one locating tab which locates it in its correct position; each grooveless bearing half contains two locating tabs which prevent inadvertent installation in the upper position. See Fig. IX-86.

CAUTION: Under no circumstances should a grooveless bearing be installed in the upper position. With all oil to that journal blocked off by the grooveless bearing, the engine can be expected to fail in only a few revolutions of the crankshaft.

Inspection

Lower main bearing can be inspected by dropping the cap nuts and cap just far enough to view the bearing surface. Completely removing the nuts is not necessary. The upper bearing half, however, can only be inspected by removing the bearing cap and then rolling the upper bearing half out of its position. It must be rolled so that the locating tab comes out first.

A bearing shell should be replaced if one-third of the bearing area is worn down to the bronze-colored copper/lead matrix. It is good practice to inspect bearings adjacent to the worn bearing also.

Removal

NOTE: Refer to LOCOMOTIVE MAINTENANCE TOOLS, GEG-14700, for specialized tools available for performing this operation.

To remove a main bearing, use the following procedure:

1. Loosen the cap nuts two to three turns.
2. Remove the bearing-cap side bolts and loosen the side bolts of the adjacent bearings.

NOTE: To facilitate removal of the cap from the frame, spread the frame slightly using a frame expander, Part 147X1314 (mechanical) or 147X1742 (hydraulic).

3. Loosen the bearing cap by tapping downward with a lead hammer or brass drift.
4. Remove the nuts and cap containing the lower half shell. Keep a firm grip on the bearing cap, as it is heavy.
5. Usually the upper half shell can be rolled out by hand. However, it may be necessary to apply the barring-over tool to the engine and a removal tool, Part 147X1342, to a crankshaft oil hole. Then rotate the crankshaft to roll the shell out in the proper direction, so that the locking tab rolls out and not in.

Handle the bearing shells carefully so they do not become damaged in any way.

Installation

Inspect the crankshaft journal to assure it is in good condition.

1. Clean the surfaces of the crankshaft journal, main frame, bearing shells and bearing cap.
2. Coat the journal and inner bearing surfaces with clean engine lube oil.
3. Roll the upper grooved bearing shell into place. To avoid damage to the bearing, assure the lock tabs are properly seated.
4. Seat the lower shell in the bearing cap.
5. Position the bearing cap on its dowel and apply the cap nuts and side bolts finger-tight. Use new O-rings on the bearing-cap side bolts, and apply Lubriplate Spray Lube "A," GE Part 147X1614, to the O-rings and the washer face and threads of the bolts. Also apply Molykote G-n, GE Part 147X1143-1, or Lubriplate to the threads and contact face of the stud bolt nuts. While either lubricant is acceptable, less torque will be required when using Molykote to achieve the stretch value for the stud bolts.
6. Tighten side bolts to approximately 75 lb.-ft. Tighten bearing cap nuts to achieve correct stud stretch value, using a stretch gage, Part 147X1860. On 8-cylinder engines, stretch studs 0.025 in. to 0.027 in. On 12 and 16-cylinder engines, stretch studs 0.027 to 0.033 in. Then torque side bolts to 265-275 lb.-ft.

Thrust Collars

Two half-ring thrust collars, fitted to the engine frame at the second main bearing from the generator end, control the axial thrust of the crankshaft. These collars are loosely fitted and are held in place by the main bearing cap and the crankshaft.

Each thrust collar is marked at its outer edge with a serial number, catalog number and drawing number.

The collars are of solid bronze, have a heavy lead-tin plate on the thrust-bearing surface and a thin lead-tin flash plate all over.

The bearing face of the collar can be identified by its radial oil grooves. WHEN INSTALLED, THE SIDE OF THE COLLAR CONTAINING THE OIL GROOVES MUST FACE THE CRANKSHAFT.

To determine if renewal of the thrust collars is necessary, the crankshaft thrust clearance should be measured. See Crankshaft End-Play in CHECKS section.

CAUTION: Consult your *Renewal Parts Catalog* for the correct thrust collar part number.

If thrust collars must be replaced, proceed as follows:

1. Remove the main bearing cap which retains the thrust collars.
2. Roll the thrust collars out of their fits in the web, Fig. IX-87.
3. Coat new thrust collars with clean lube oil and install, making sure the oil grooves face the crankshaft.

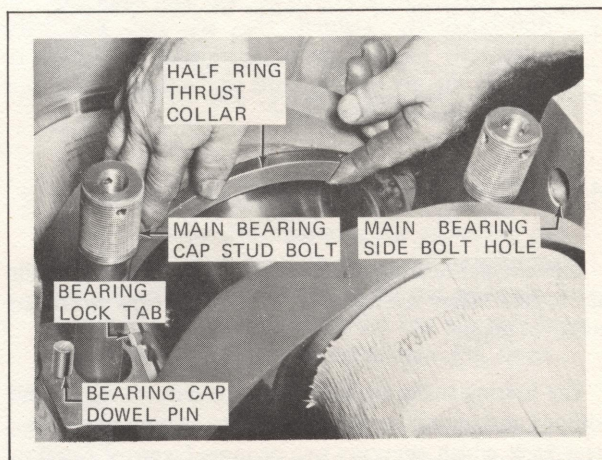


FIG. IX-87. INSTALLING THRUST COLLARS.

FIG. IX-87, E-9914A

FIG. IX-88, E-16540

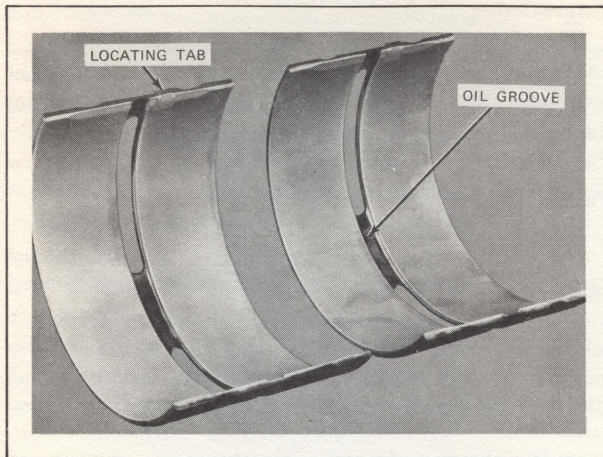


FIG. IX-88. CONNECTING ROD BEARING SHELLS.

4. Check thrust clearance.
5. Install main bearing cap.

CONNECTING ROD BEARINGS

The connecting rod bearing shells, shown in Fig. IX-88, are precision-type and are replaceable without machining or scraping. They are constructed with a solid steel back which is plated on the running surface with specially formulated bearing metals. Each shell has a locating tab which properly locates and secures it in position in the rod or in the cap. Any shell may be applied in either position, as shells are interchangeable. Each bearing shell is stamped along its radial edge with a serial number, a part number and a catalog number.

CAUTION: *The locating tab slot is on one side only of the rod and the rod cap. The tab on the shell must be positioned in the slot, or it will be crushed in and cause a bearing failure and, possibly, further serious damage.*

Connecting rod bearings may be replaced without removing the connecting rod from the engine. Bearings are replaced as follows:

1. Bar the engine to position the journal near its topmost position.
2. Loosen the cap bolts several turns. Use 1-1/8 in. socket, Part 147X1866, and ratcheting torque wrench, Part 147X1823. See Fig. IX-83.
3. Tap the bearing cap sideways with a heavy brass bar. The cap will separate from the journal. Remove the nuts and cap.

4. Block or otherwise secure the piston and rod in its upper position and bar the engine over to get the journal out of the way.
5. Using a wood or fiber block as a drift, tap the bearing shells out of their fits.
6. Clean the bearing shell fits to make sure there are no high spots. File off any high spots on the split line of the rod and cap. Stone off any high spots on the back of the bearing shells. **DO NOT LUBRICATE BETWEEN THE ROD BORE AND THE BEARING SHELLS.**
7. Verify that the lock tabs on the shells are properly positioned and tap the shells into place with a wood or fiber drift. **DO NOT USE ANY METAL OBJECT AS A DRIFT.**
8. Lubricate the rod journal with clean lube oil. Bar the engine to position the rod journal up close to the rod and lower the piston and rod assembly onto the journal.
9. Coat the threads and washer faces of the cap bolts with Molykote G-n, Part 147X1143-1. Tighten the bolts in increments of 100-125 lb.-ft. to a final torque of 400-420 lb.-ft.

CROSSHEADS AND GUIDES

Three crosshead assemblies are mounted in the engine frame under each cylinder. The crossheads transmit reciprocating force from the cams to the push rods to operate the valves and the fuel injection pump on each cylinder, Fig. IX-89.

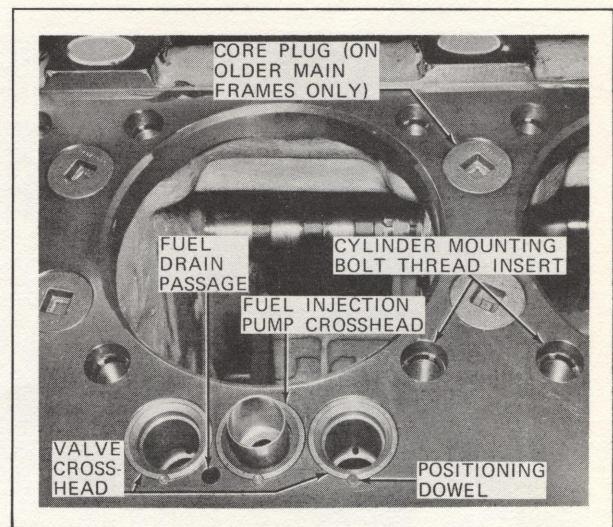


FIG. IX-89. CYLINDER LOCATION WITH CROSSHEADS INSTALLED.

FIG. IX-89, E-14927A

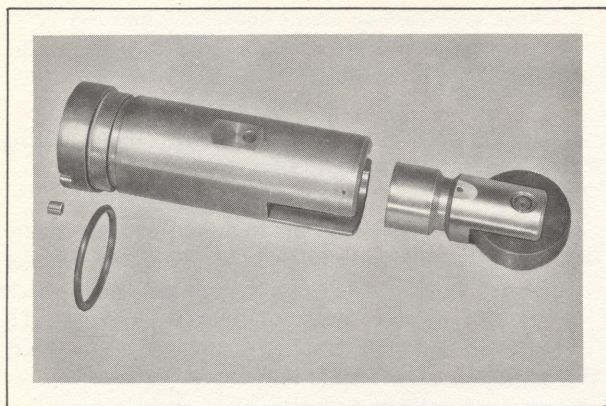


FIG. IX-90. VALVE CROSSHEAD AND GUIDE ASSEMBLY.

The assemblies for the air and exhaust valves are alike and consist of two major parts: the crosshead with its hardened roller, and a guide in which the crosshead operates, Fig. IX-90.

Parts of the fuel crosshead assembly are similar in appearance, but are not interchangeable with those for the valves. The fuel crosshead assembly consists of the following major parts: a guide, spring retainer, spring and crosshead. The fuel crosshead assembly, when installed in the engine, is spring-loaded to insure the crosshead and its roller will run smoothly on the lobe of the camshaft, Fig. IX-91.

Valve Crosshead Guides

The valve crosshead guides are identical and interchangeable. They are individually positioned in their

bores in the main frame by dowel pins and are held down by the flange of the cylinder above them. An O-ring around each guide, near its upper end, forms an oil seal between the guide and its frame bore. Another O-ring forms a seal between the cylinder base and the crosshead guides.

Fuel Crosshead Guides

The fuel crosshead guide is positioned and sealed in the same manner as the valve crosshead guides. It differs from those for the valves in having a wider roller guide slot to accommodate the wider roller, a larger crosshead to guide locking pin hole, and a different machining arrangement on its inside diameter to properly position the spring retainer.

Valve Crossheads

Two designs of crossheads have been used and they are:

1. Part 124X1033-4 — Used until early 1978. This crosshead had a hardened push rod bearing at its upper end, and a hardened cam roller operating on a free-floating steel bushing at its lower end.
2. Part 124X1068 — Used starting in early 1978. This crosshead had a hardened push rod bearing at its upper end, and a hardened cam roller operating on a bronze pin at its lower end.

Both crossheads are interchangeable as a complete assembly and can be used in either the air or exhaust position.

Drilled oil passages in the crosshead and crosshead guide and an annular groove around the crosshead permit intermittent oil flow upward through each valve push rod to lubricate the upper cylinder parts.

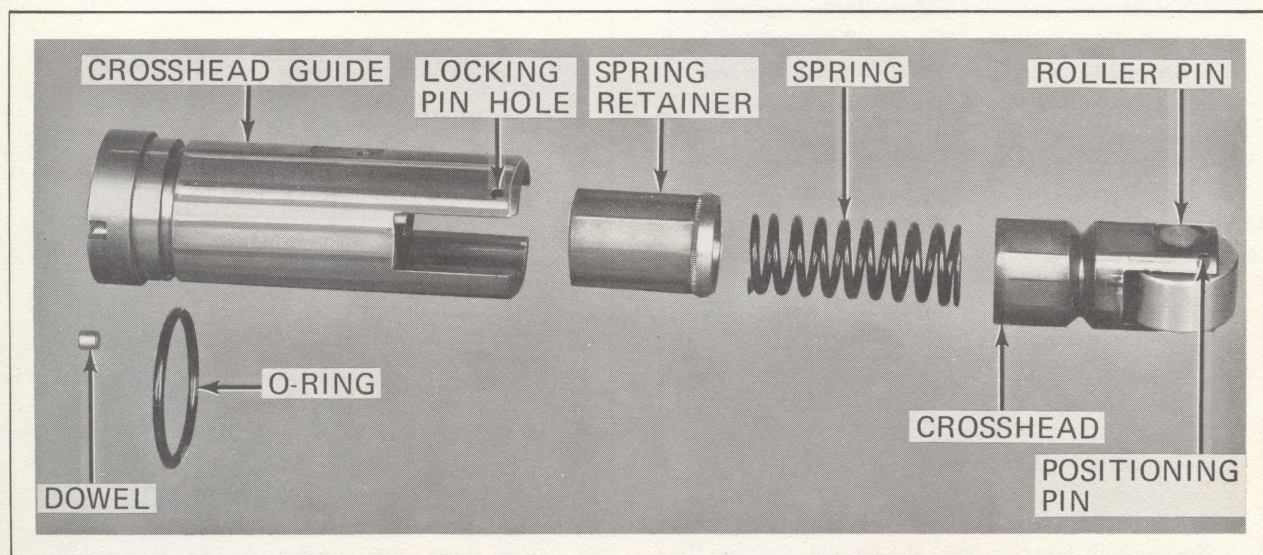


FIG. IX-91. SPRING-LOADED FUEL CROSSHEAD AND GUIDE ASSEMBLY.

FIG. IX-90, E-9925

FIG. IX-91, E-14928

Fuel Crossheads

Fuel crossheads are similar in appearance, but are not interchangeable with valve crossheads. They are arranged with different oil passages and can be identified by the flat tappet-rod bearing insert at their upper end. The fuel crossheads have a wider cam roller which is held in place by a large roller pin and a positioning pin, Fig. IX-91.

Removal and Installation

After the cylinder has been removed, the crosshead assemblies and positioning dowel pins can be pushed upward and removed. To lock the valve crosshead in its guide, bend a piece of 1/16-in. iron wire about one in. long into an "L" shape. Push the crosshead up in its guide, and insert the lockwire through the 1/8-in. locking hole from the guide bore outward. The end of the wire must not protrude beyond the guide, or it will interfere during guide removal. Use the same procedure for locking the fuel crosshead in its guide as is used for the valve crosshead, but use a 3/16-in. wire in 1/4-in. guide locking hole.

A crosshead and guide may be renewed without completely removing the cylinder. With the piston at top dead center, disconnect the cylinder and lift it just high enough to permit removal of the crosshead assembly, but not high enough to disengage the piston rings from the cylinder bore. Immerse crosshead in SAE-10 lubricating oil for five minutes, then install the new crosshead assembly with lubricant applied to the sealing O-ring. Position the assembly and insert the dowel. Apply new O-rings to the push rod ferrules. Then restore the cylinder to position and reconnect.

NOTE: Use care when handling crossheads and guides. Burrs may be formed on the edge of the guide bore if the crosshead is dropped into the guide with the guide inverted. Burrs must be removed to prevent binding of the crosshead during operation. Also, in case of a push rod failure, the crosshead will probably be stuck in the guide and should be carefully inspected for damage.

RUBBER-BONDED PUMP DRIVE COUPLING

The pump drive gear assembly is mounted on the crankshaft and is used to transmit the torque, needed to drive the water and lube oil pumps, from the crankshaft to the pump idler gear. The assembly consists of the following basic parts, Fig. IX-92:

1. Gear hub
2. Gear ring
3. Gear coupling.

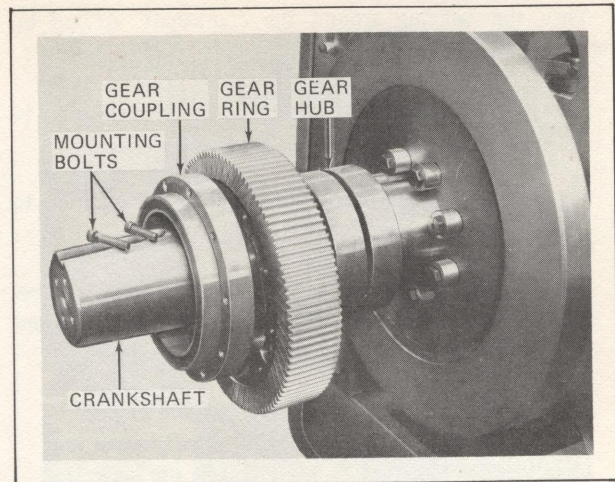


FIG. IX-92. TYPICAL PUMP DRIVE GEAR ASSEMBLY.

The gear coupling is made of two basic parts, the clamp ring and the coupling, which are put together with a press fit. The coupling has an inner flange and an outer sleeve held together with a bonded resilient material, Fig. IX-93.

Coupling Replacement

NOTE: To gain access to the coupling, it is first necessary that the drive hub and guard be removed from the forward end of the engine. It is also necessary to remove the lube-oil fill assembly from the left side of the forward-end cover, and remove the bearing from the forward-end cover.

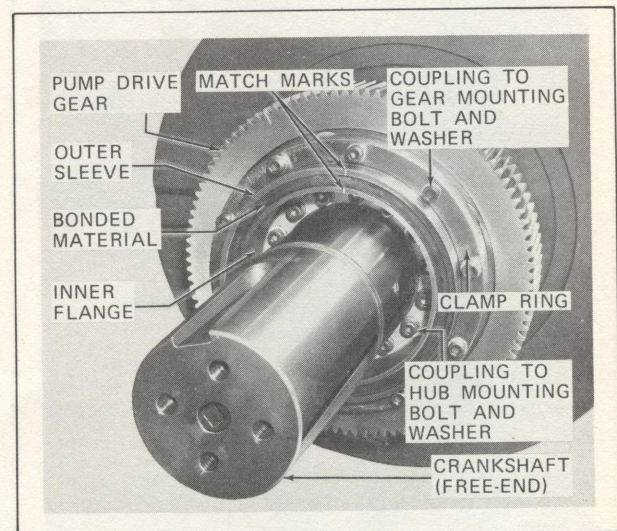


FIG. IX-93. FRONT VIEW OF PUMP DRIVE GEAR ASSEMBLY.

Thru the opening around the crankshaft, created by removing the bearing:

1. Remove the bolts and washers holding the coupling to the gear.
2. Remove the bolts and washers holding the coupling to the hub.
3. Remove the defective coupling, install a new coupling, and secure to hub and gear with bolts and washers. Tighten bolts to 44-49 lb.-ft. of torque.

NOTE: It may be necessary to bar the engine, or rotate the gear, to achieve bolt-hole alignment and alignment of match-mark numbers on the back face of the hub and gear. See Figs. IX-94 and IX-95.

4. Replace forward-end bearing, other parts removed from the forward end of the engine and the lube-oil fill assembly.

OVERSPEED-DERATER LINK

Removal

With the engine shut down:

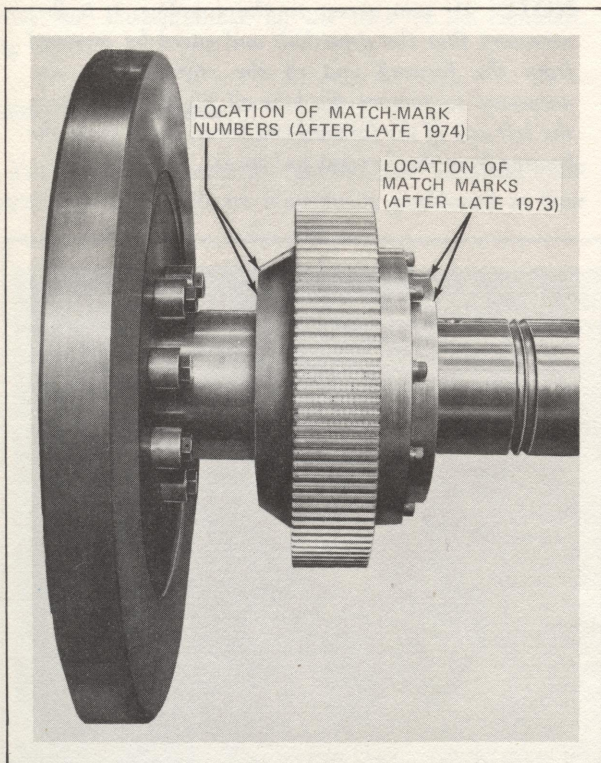


FIG. IX-94. SIDE VIEW OF PUMP DRIVE GEAR ASSEMBLY.

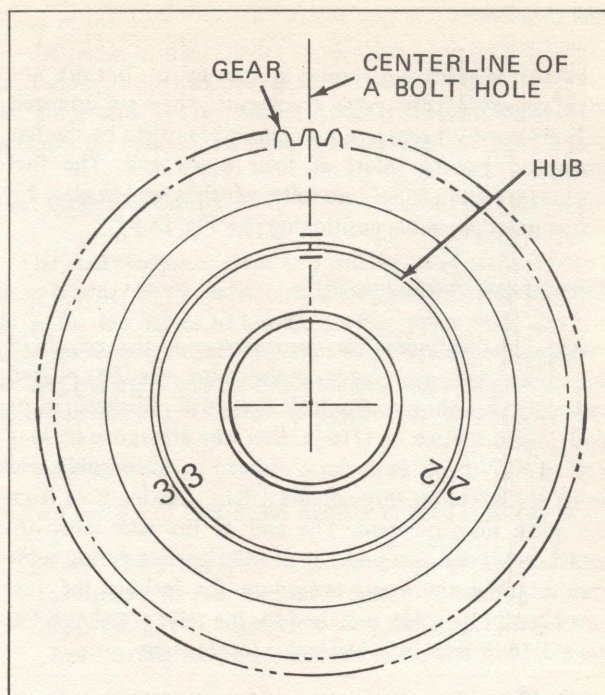


FIG. IX-95. MATCH-MARK NUMBERS ON BACK (FRAME) SIDE OF HUB AND GEAR.

1. Disconnect the air and oil lines at the link, Fig. IX-96.
2. Remove the cotter pins and clevis pins which connect the link to the control governor and the fuel-control linkage.
3. Remove the 90-degree fitting from the air inlet in the top cover of the link.

Installation

1. Install the 90-degree fitting in the air inlet in the top of the link.
2. Position the link and install the clevis pins which connect the link to the control governor and the fuel-control linkage. Secure clevis pins with new cotter pins.
3. Connect the air and oil lines to the links.
4. Check the fuel injection pump rack settings and make adjustments as required. See Fuel Pump Rack Setting in ADJUSTMENTS section.
5. Start the engine and check for proper operation of the link. Also check for leakage at the hose connections and the I.D. of the outer casing.

FIG. IX-94, E-14934A

FIG. IX-95, E-21433

FIG. IX-96, E-14950A

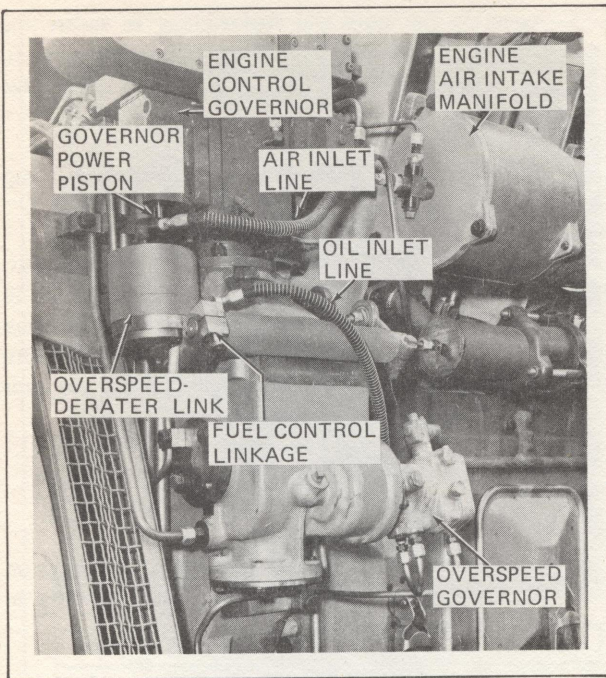


FIG. IX-96. VIEW OF OVERSPEED-DERATER LINK MOUNTED ON ENGINE.

FIG. IX-97, E-21624

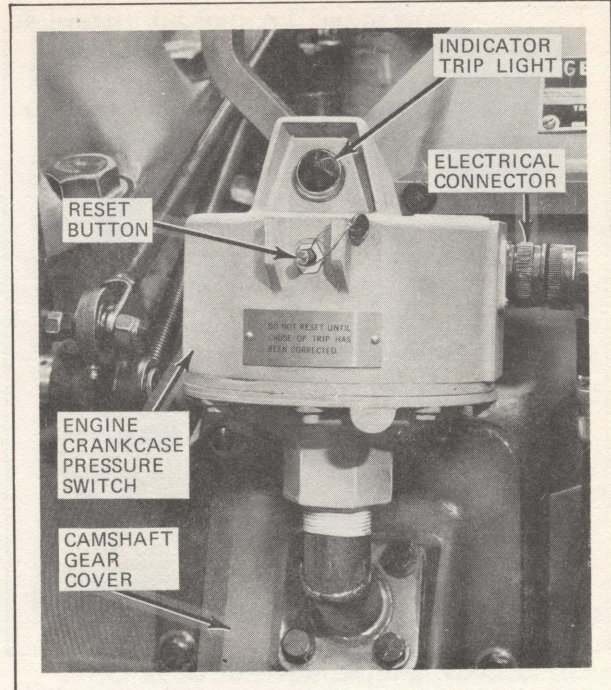


FIG. IX-97. ENGINE CRANKCASE PRESSURE SWITCH MOUNTED ON ENGINE.

CRANKCASE PRESSURE SWITCH

Removal and Installation

The crankcase pressure switch is an important protective device and should be immediately replaced if found defective.

To remove it, disconnect the electrical connector and remove the four mounting bolts and lockwashers. When installing a replacement, use a new gasket at the mounting flange. Secure with four mounting bolts and lockwashers. Connect the electrical connector, push in the reset button and apply seal wire and seal.

OVERSPEED GOVERNOR

Removal and Installation

To remove the overspeed governor, disconnect the oil supply line, oil drain line and pressure line to overspeed link. Cap the lines to keep out dirt. Remove the four mounting bolts and pull the governor straight out off its spline. Remove the protective caps from the replacement governor and cap the holes in the old governor with them.

Clean off old gasket material and mount the new governor using a new gasket. Reconnect all piping and push in reset button. Check for leaks after the engine is started.

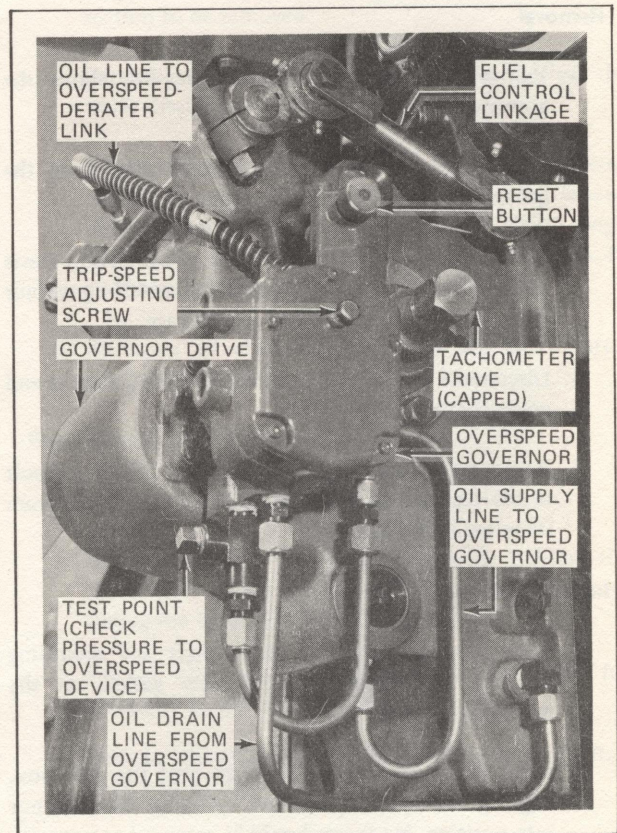


FIG. IX-98. OVERSPEED GOVERNOR.

FIG. IX-98, E-25557

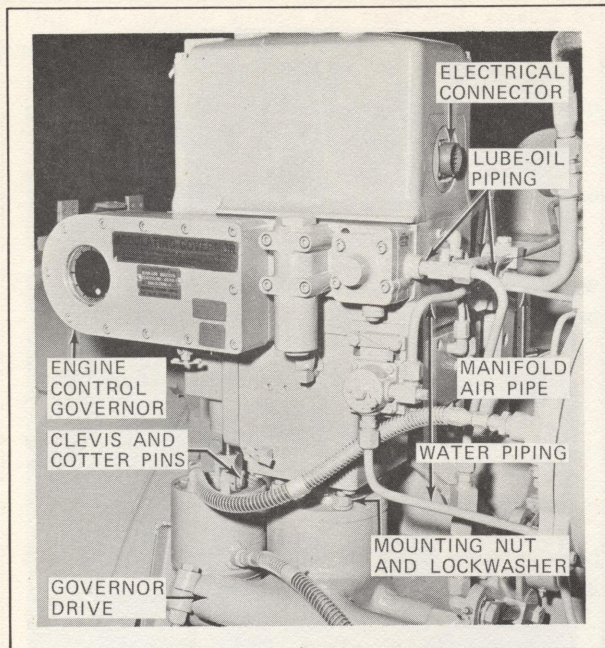


FIG. IX-99. ENGINE CONTROL GOVERNOR.

ENGINE CONTROL GOVERNOR

Removal

1. Remove the hatch in the engine cab above the governor.
2. Disconnect the electrical connector plug from the governor.
3. Remove the cotter pin from the power piston clevis and remove the clevis pin to disconnect the governor from the overspeed link and fuel linkage.
4. Disconnect air, oil and water lines to the governor and cover the ends of all fittings.
5. Remove the mounting nuts. Install a 3/8-in. eyebolt in the top case and lift the governor straight up from its spline in the gear box.

Installation

1. Make sure the governor drive shaft and mounting surfaces are clean. Install a new gasket on the mounting surface.
2. Hoist the governor into position over the gear box, aligning the spline drive and lowering the governor into position. No force should be required to properly seat the governor.

3. Assemble the nuts and lockwashers to secure the governor in position. Reconnect the overspeed link to the power piston tail rod, making sure the linkage does not bind.
4. Reconnect all the external piping and tighten fittings securely.
5. Add oil to the line on the sight glass but not over. After the engine is run, purge the governor of all entrapped air. It may be necessary to add a little more oil as the internal chambers of the governor fill with oil. Don't overfill. There is enough oil in the governor if it is visible in the sight glass.

NOTE: Refer to governor instructions, GEI-81978 (in backshop manual) for air purging procedure.

6. Attach the electrical connector. Adjust the racks on the fuel pumps. See Fuel Pump Rack Setting in ADJUSTMENT section.

EXHAUST MANIFOLD — MULTI-PIPE

The multi-pipe exhaust manifold is used on all locomotives equipped with an 8-cylinder engine.

Removal

For the pipe section being removed, remove bolts, lockwashers and hardened flat washers at the two cylinders and at the turbocharger.

NOTE: When necessary, remove a good top pipe section to gain access to a bad lower pipe section.

Installation

1. Before installing pipe sections on the engine, wire brush all bolt threads and retap all threaded holes. Apply high-temperature anti-seize thread compound, Part 147X1640, to all threads of bolts and tapped holes and to the washer face of the bolt heads. Use new gaskets and coat both gasket faces with anti-seize compound, Part 147X1640. Applying anti-seize compound in the manner described will facilitate future disassembly.
2. Apply pipe section in place and install all bolts finger-tight. Use bolts and lockwashers at the cylinder connections; use bolts and hardened flat washers at the flange clamps at the turbocharger. See Figs. IX-100 and IX-104.

FIG. IX-100, E-17756

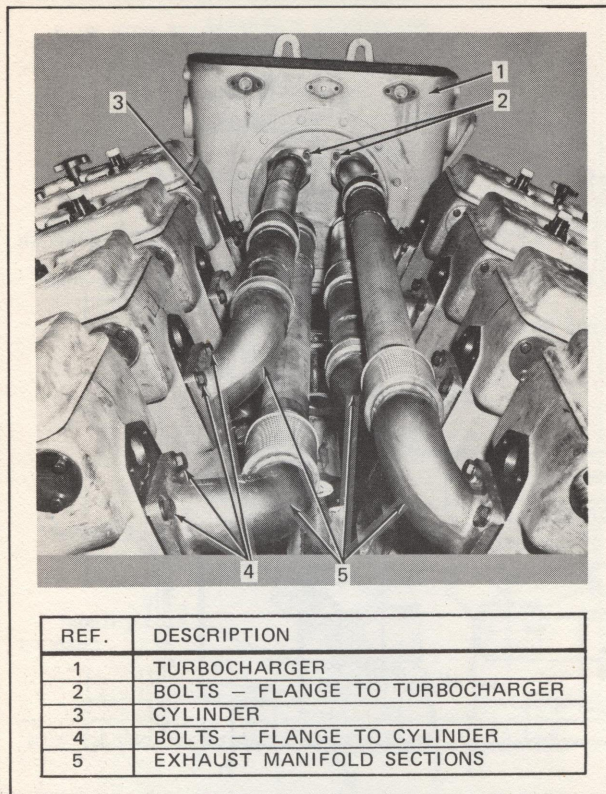


FIG. IX-100. MULTI-PIPE EXHAUST ARRANGEMENT.

3. Center all exhaust manifold flanges at the turbocharger between the two securing bolts and the two prick-punch marks on the face of the turbine-inlet flange. Alternately tighten each bolt in increments up to the final torque of 120-130 lb.-ft. (163-176 N·m). Loosen each bolt and retighten to the final torque value.
4. Check the fit of the manifold to the turbocharger. The assembled manifold flange must be square with the face of the turbocharger within 0.020 in. (0,5 mm). For example, if the flange touches the face of the turbocharger at one point, a 0.020 in. (0,5 mm) feeler gage shall not enter the joint face anywhere around the circumference.
5. Tighten the flanges at the cylinder, tightening the bolts alternately in increments, and in a criss-cross pattern, up to the final torque value of 100-110 lb.-ft. (136-149 N·m). Loosen each bolt and retighten to the final torque value.
6. After engine is started, check all connections for exhaust leakage.
7. After a few hours of operation, retighten all bolted connections.

EXHAUST MANIFOLD — SINGLE-PIPE

The single-pipe exhaust manifold is used on all locomotives equipped with a 12 or 16-cylinder engine.

Replacement of Main Section

To replace a manifold main pipe section, perform the following steps:

NOTE: Any main pipe section may be replaced without removing the water header. Carefully clean elbow joint parts and inspect for nicks which will not seal. Seal rings are reusable.

1. Unbolt the elbow clamp rings on the elbows attached to the section to be removed, and on the left and right elbow of section just ahead of this one.
2. Remove the cylinder mounting bolts on the two elbows attached to the section to be removed. Also remove the elbow mounting bolts from the cylinder just ahead of the section to be removed. Remove elbows.
3. Remove the main clamp rings from both ends of the section to be removed.
4. Carefully lift out the section, rotating to clear the water discharge header.
5. Install the new section in the reverse order, being careful to align the section to the mounted elbows before torquing the main and elbow clamp rings. Torque the main pipe clamping bolts to 70-75 lb.-ft. and the elbow clamping bolts to 18-20 lb.-ft.
6. Retorque all clamping ring bolts one month after section replacement.

Replacement of Transition Section

To replace a transition section, proceed as follows:

1. Remove the top six socket-head bolts holding the turbo inlet casing to the turbo housing (to permit sliding the transition section straight up).
2. Unbolt the elbow clamp rings and elbows for cylinders 1L and 1R, and remove the elbows.
3. Remove the clamp ring at the forward end of the first main pipe section.
4. Remove the clamp-ring bolts which secure the transition section to the turbocharger.

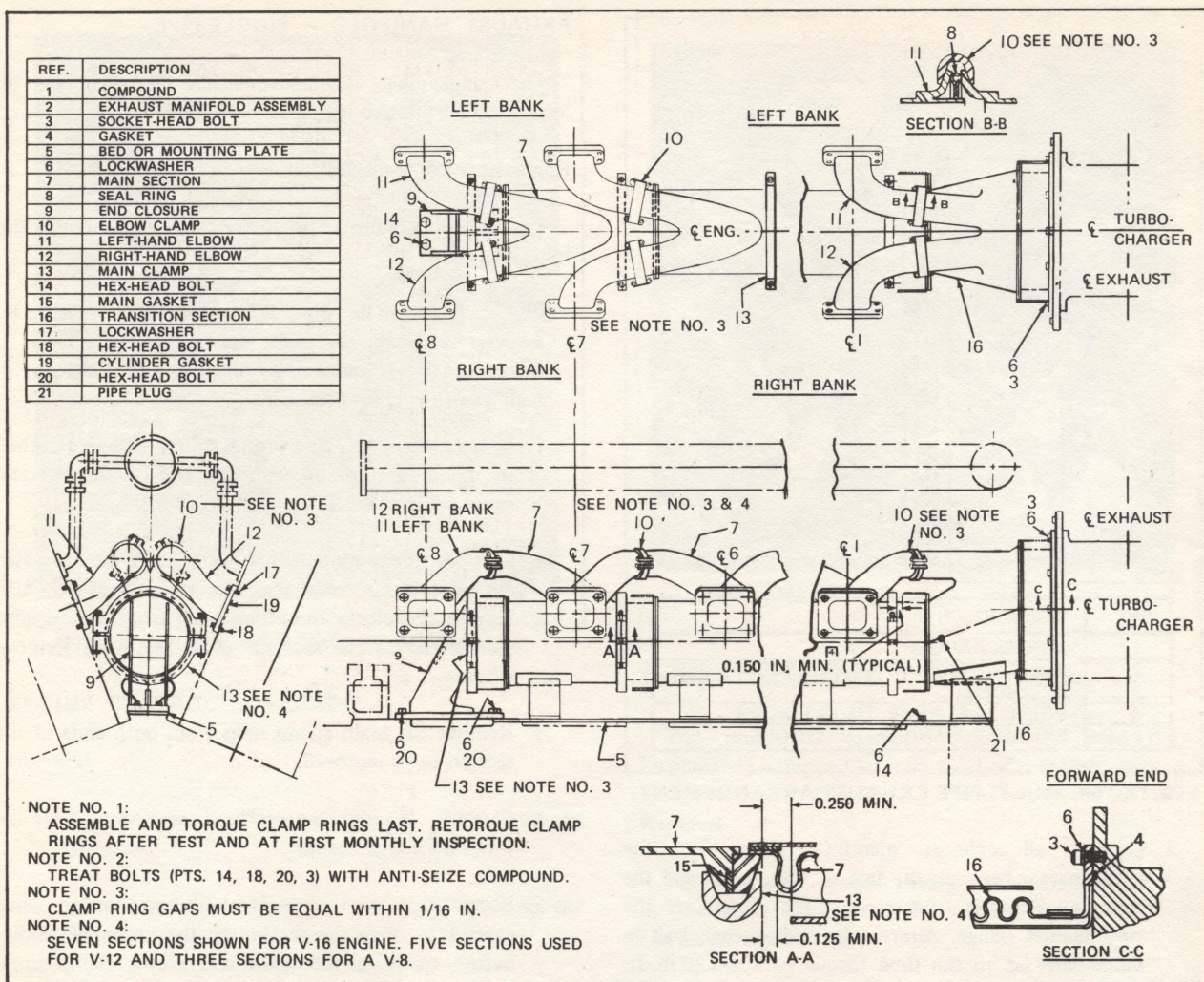


FIG. IX-101. SINGLE-PIPE MANIFOLD.

- Lift this section up and out toward the left side of the engine.
- Reverse these procedures to install a new section. Torque the manifold clamping bolts to 70-75 lb.-ft. and the manifold to turbo inlet clamp bolts to 70-75 lb.-ft. Torque the cylinder exhaust port to manifold elbow bolts to 100-110 lb.-ft.
- Retorque all bolts one month after section replacement.

Seal Rings

The seal rings between manifold sections and cylinder elbows may be reused if they are within the dimensional limits as shown in Fig. IX-102 and if the sealing surface is not nicked or dented.

When installing a seal ring, make sure that the spring wire retainer is on the side toward the cylinder connection. The manifold elbow has clearance to accommodate this retainer. Should the ring be put on with the spring retainer toward the main section, clearance will be lacking and a leak will probably result. See Fig. IX-103 for correct application of seal ring retainer.

TURBOCHARGERS

General

Since several different models of turbochargers are used on General Electric diesel engines, the replacement instructions that follow will be all inclusive. Therefore, disregard operations that are not applicable.

FIG. IX-102, E-23572

FIG. IX-103, E-23573

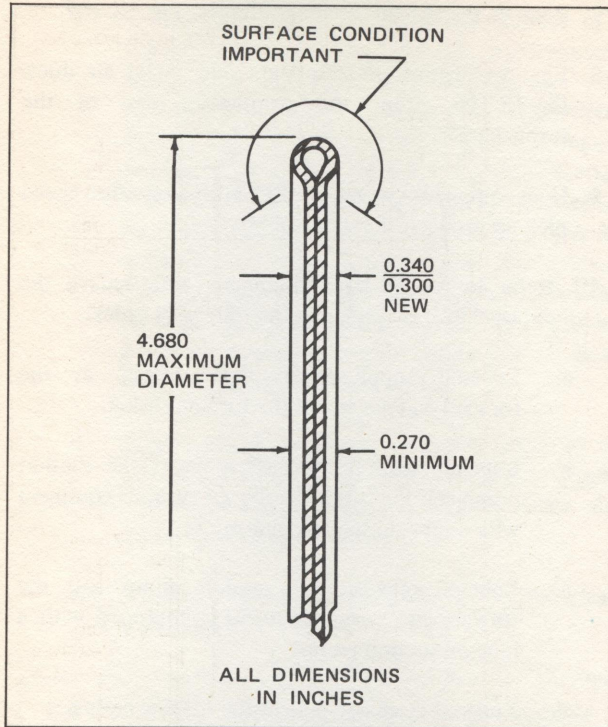


FIG. IX-102. SEAL RING DIMENSIONAL LIMITS.

Removal

1. Drain the locomotive cooling water system.
2. Remove the hatch over the turbocharger.
3. Disconnect the crankcase breather from the exhaust stack, Fig. IX-107. Remove the four aspirator hoses, Fig. IX-106. Remove the exhaust stack from the turbocharger turbine casing.
4. Remove the intercooler support bar, Fig. IX-105.
5. Remove the two compression couplings from the water discharge header, Fig. IX-105.

FIG. IX-104, E-23321

FIG. IX-105, E-24458

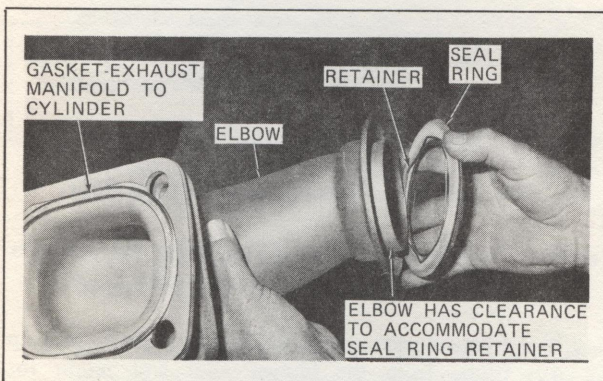


FIG. IX-103. SEAL RING RETAINER CORRECTLY APPLIED.

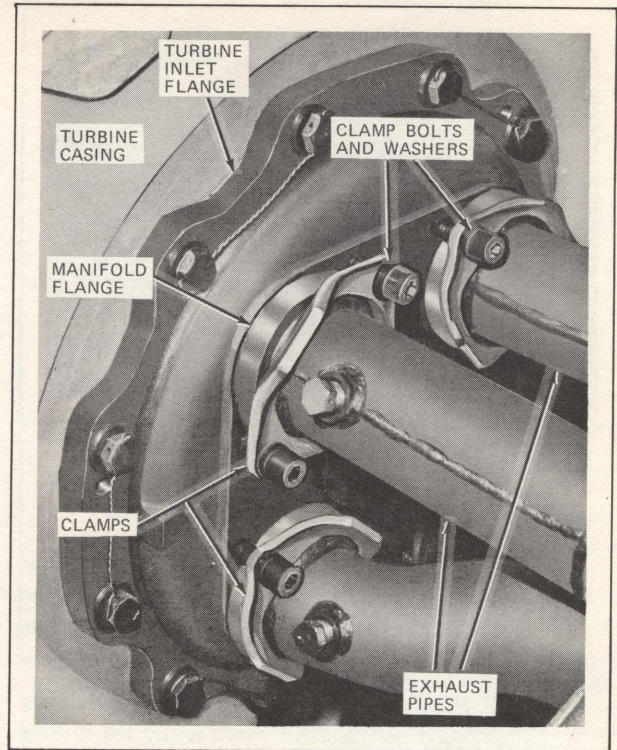


FIG. IX-104. TURBO INSTALLATION DETAILS - TURBINE END, WITH MULTI-PIPE EXHAUST MANIFOLD.

6. Disconnect the exhaust manifold from the turbine inlet assembly as follows:

- a. For multi-pipe manifold:

Remove the bolts and heat-treated washers from each clamp, Fig. IX-104.

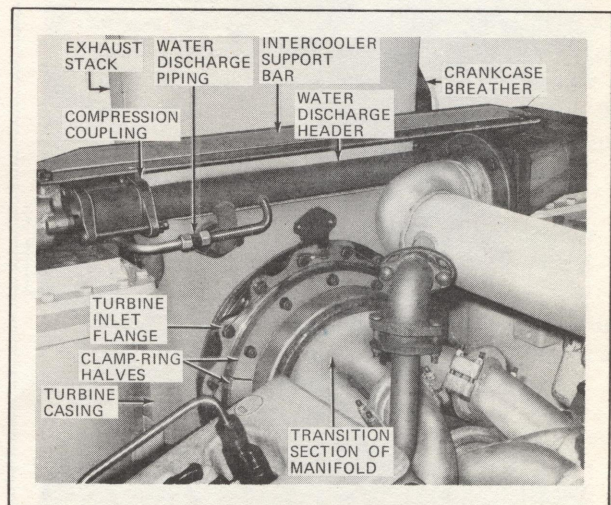


FIG. IX-105. TURBO INSTALLATION DETAILS - TURBINE END, WITH SINGLE-PIPE EXHAUST MANIFOLD.

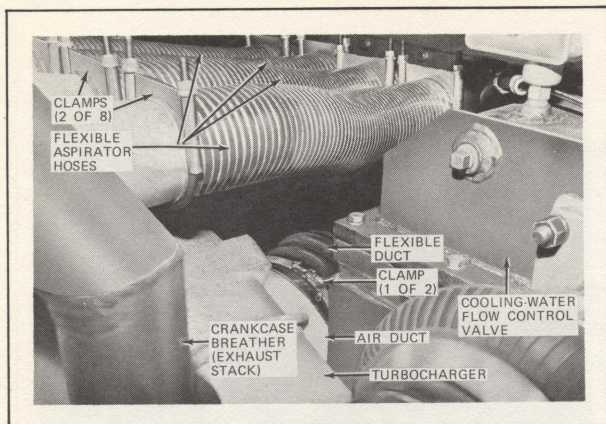


FIG. IX-106. TURBO INSTALLATION DETAILS, COMPRESSOR END.

b. For single-pipe manifold:

- (1) Remove bolts and lockwashers which secure the clamp-ring halves, Fig. IX-105, to the turbine inlet flange. Remove the clamp-ring halves.
- (2) Remove the lockwires and the four lower bolts and washers which secure the turbine inlet flange to the turbine casing.

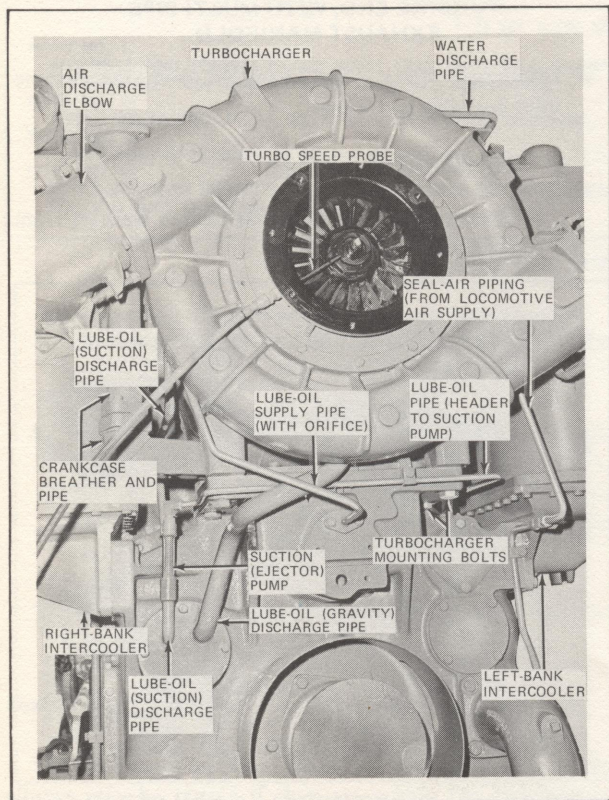


FIG. IX-107. TURBO INSTALLATION DETAILS, COMPRESSOR END.

7. Remove the two air-discharge elbows, Fig. IX-107.

8. Remove clamps, flexible duct and metal air duct, Fig. IX-106, from the compressor end of the turbocharger.

9. If so equipped, disconnect the CHEC-excitation speed pick-up probe at the terminal box.

10. Refer to Fig. IX-107. Disconnect and remove the external lube-oil piping in the following order:

- a. Lube-oil supply pipe, with orifice, at the forward-end cover and the turbine casing.
- b. Lube-oil suction discharge pipe at the suction pump and the turbine casing (if turbo is equipped with a lube-oil suction pump).
- c. Lube-oil pipe at the suction pump and the forward-end cover (if turbo is equipped with a lube-oil suction pump).
- d. Lube-oil discharge pipe at the turbine casing.
- e. The cover-discharge pipe together with the suction pump from the forward-end cover.

11. Disconnect the seal air piping at the turbine casing (if turbo is supplied seal air from the locomotive air supply).

12. Remove the four mounting bolts and lockwashers, Fig. IX-107, which secure the turbocharger to the forward-end cover.

13. Use lifter and/or lifting sling to remove turbocharger from engine. Slightly rock the turbocharger, as it is lifted, to free the two rear feet from their locating dowels.

CAUTION: Exercise care in removing the turbocharger so as not to damage the exhaust manifold.

14. After positioning the turbocharger on the floor:

- a. Remove the water discharge header and retain for application on the replacement turbocharger.
- b. Remove the CHEC-excitation speed pick-up probe from the blower inlet and retain for application on the replacement turbocharger (if turbo was equipped with probe).

FIG. IX-106, E-24460

FIG. IX-107, E-24459

- c. If the turbocharger was removed because of a failure (and not for a periodic replacement), thoroughly examine the turbocharger and **DETERMINE THE CAUSE OF FAILURE**. Failure to do so will probably result in a repeat failure. If failure was caused by foreign material, it is **MANDATORY** that all traces of this material be removed from the system; that is, it may be necessary to remove and clean the exhaust manifold, or it might be necessary to remove the air filters and clean and inspect the filter clean-air plenum. Also inspect the inlet side of both intercoolers for foreign material.
- d. Apply protective covers and pipe plugs to all openings in the removed turbocharger. Apply new covers and plugs or remove from the replacement turbocharger.
- e. Remove the crankcase breather cover and clean the screen assembly.

CAUTION: If turbocharger is being replaced because of bearing failure, check the cavity in the top of the forward-end cover when the screen assembly is removed; make certain the pipe-tapped hole is fitted with a pipe plug. Failure to plug this hole will result in a loss of lube-oil supply to the turbocharger bearings.

Installation

If turbocharger is being installed as a result of a failure (and not for a periodic replacement), correct the cause of the failure. Apply new gaskets and lockwashers and install turbocharger in the following manner:

1. From the replacement turbocharger, remove all protective covers and the pipe plugs from the lube-oil and seal-air inlets (if so equipped). Make certain no foreign material is in the turbocharger.
2. Pour some clean engine lube oil into the oil inlet near the top of the turbine casing, and rotate the rotor assembly several revolutions.
3. Using new gaskets, assemble the water discharge header, Fig. IX-105, to the turbine casing.
4. If so equipped, install the CHEC-excitation speed pick-up probe. Check gap between end of probe and outside diameter of rotor cap, which must be 0.028-0.090 in. (0,711-2,286 mm). See Fig. IX-108.

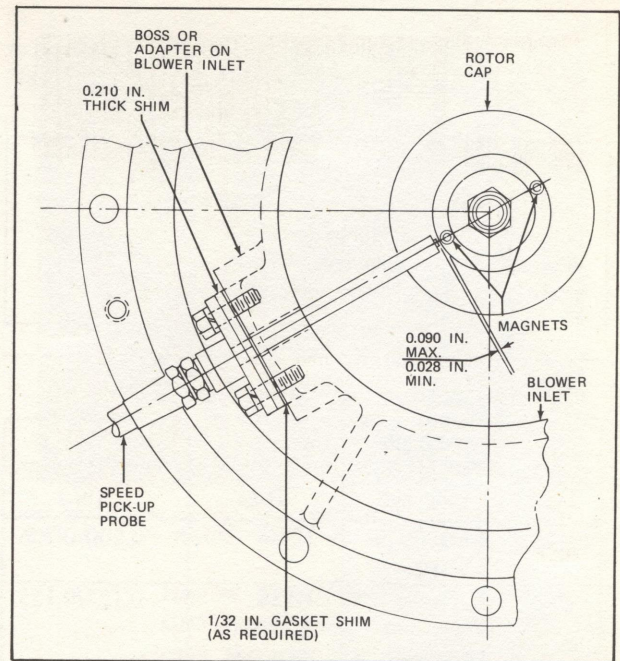


FIG. IX-108. AIR INLET VIEW OF TURBOCHARGER.

CAUTION: If speed pick-up probe is not used, apply a suitable cover plate, Part 126X1545, over the probe hole. Otherwise, harmful dirt will be pulled into the turbo thru the probe hole and delivered into the engine.

5. Clean the mounting surface of the forward-end cover and deburr the locating dowels, if required. Apply a light film of grease to the two dowels, and install two new O-rings around the water supply openings.
6. Using a suitable lifter and/or lifting sling, hoist and raise the turbocharger. Clean and deburr (if required) the four mounting feet. Position the turbocharger to align the two dowel holes in the rear feet with the locating dowels. Slightly rock the turbocharger while lowering it onto the forward-end cover.

CAUTION: Exercise care while installing the turbocharger to avoid damaging the exhaust manifold.

7. Using new lockwashers, assemble the four mounting bolts. Using mounting bolt wrench set, Part 147X1952, tighten bolts with a torque of 150-165 lb.-ft. (203-224 N·m).

NOTE: When using mounting bolt wrench set, Part 147X1952, apply 93-103 lb.-ft. (126-140 N·m) of torque (as indicated on the torque wrench) to achieve the 150-165 lb.-ft. (203-224 N·m) of torque required on the mounting bolts.

8. Wash and blow out all lube-oil piping, then refer to Fig. IX-107 and assemble them in the reverse order used at removal. Refer to Step 10 under "Removal" section.

CAUTION: The lube-oil supply pipe must have an orifice in the flange that is open and must be of the correct size to assure correct lube-oil pressure and flow to the turbocharger bearings. Orifice diameter must be per Table IX-V.

TABLE IX-V, ORIFICE SIZES

Engine Type	Engine Max. Speed	Turbo Type	Orifice Diam. (in.)
FDL8	1000 or 1025	H584	0.200/0.196
FDL8	1050	H584, BC370 or 7S1408	0.157/0.155
FDL12	1025 or 1050	H581 or 7S1412	0.157/0.155
FDL16	1000 or 1025	H581	0.157/0.155
FDL16	1025 or 1050	BCO65 or 7S1616	0.352/0.348
FDL16	1050	BCO80 or 7S1616	0.352/0.348

9. Connect the seal air piping to the turbine casing (if turbo is supplied seal air from the locomotive air supply).
10. If used, connect the CHEC-excitation speed pick-up probe at the terminal box.
11. Assemble the metal air duct to the compressor end of the turbocharger. Assemble the flexible duct and secure with two clamps, Fig. IX-106.
12. Assemble the two air-discharge elbows between the turbocharger and the intercoolers in the following manner:

- A. Inspect the elbows and flanges. Pay particular attention to the four lugs on each elbow. Make sure they are all present, square and the welds holding them to the elbow are not cracked. Replace or repair any elbows that have defective lugs or fewer than the required four. Check O-ring seats for wear. Don't use the elbow if those seats are worn appreciably. Leaks will result.

- B. Install the two studs in each intercooler, using lockwashers under the nuts. Torque the nuts to 55-60 lb.-ft. (75-81 N·m). Apply an extra nut and lockwasher on each stud. Run the nut up near to the stud-locking nut, with the lockwasher on the outside, ready to bear against the elbow lug.
- C. Screw two more studs into each of the turbo-end bolting flanges. Do not thread studs through the flanges. If this is done, it will be impossible to make a tight seal between flange and turbocharger. Use lockwashers under the nuts and torque to 55-60 lb.-ft. (75-81 N·m). Again, apply an extra nut and lockwasher on each stud, positioning them as was done on the intercoolers.
- D. Preassemble the two elbows and flanges, using new red O-rings, Part 115X1902. Do not use Part 115X1268 black O-ring ahead of the intercooler. It will not withstand the higher air temperature. Before applying the O-rings, lubricate with Lubriplate Spray Lube "A," Part 147X1614. This reduces the probability of O-ring damage during installation.
- E. Slide the turbo-end flange (with O-rings) onto the elbow. Take care not to disturb the O-ring in the flange groove. Make certain the studs enter the holes in the lugs. Loosely apply lockwashers and nuts to the outer end of the studs.
- F. Apply the elbow, with preassembled flanges and O-rings, to the engine. The shorter end goes into the turbo; the longer one into the intercooler. Position elbow so each end enters its hole squarely.

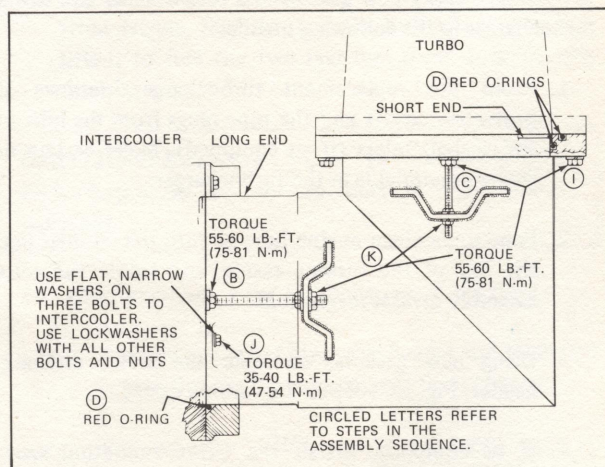


FIG. IX-109. TOP VIEW OF RIGHT-HAND TURBO AIR ELBOW INSTALLATION. CIRCLED LETTERS REFER TO STEPS IN THE ASSEMBLY SEQUENCE.

FIG. IX-109, E-23340A

- G. Finger-tighten the four bolts (with lockwashers) attaching the turbo-end flange.
 - H. Then slide the flange and O-ring into position against the intercooler. Install and finger-tighten the three bolts with flat, narrow washers in that flange.
 - I. Again, check to make certain the elbow is squarely positioned and all four studs are through their respective lugs. Then, tighten the four bolts on the turbo-end flange evenly, in a criss-cross pattern, to 55-60 lb.-ft. (75-81 N-m).
 - J. Torque the three bolts on the intercooler flange evenly to 35-40 lb.-ft. (47-54 N-m).
 - K. Run the inside nuts and lockwashers on the studs up against the lugs until they touch plus 1-1/2 to 2 turns. Then, torque the outside nuts to 55-60 lb.-ft. (75-81 N-m). Use two wrenches simultaneously, if necessary, to keep the studs from turning. Do not bend or distort the lugs during this operation.
13. Connect the exhaust manifold to the turbine inlet assembly as follows:
- a. For multi-pipe manifold, Fig. IX-104:
 - (1) Using high-temperature anti-seize thread compound, Part 147X1640, coat both sides of four new gaskets.
 - (2) Make sure all manifold to turbocharger bolt threads are clean. If necessary, wire-brush all bolt threads and retap all threaded holes. Apply high-temperature anti-seize thread compound to all threads of bolts and tapped holes and to the washer face of bolt heads.
 - (3) With gaskets in place, assemble all bolts and hardened washers finger-tight. Center each exhaust manifold flange at the turbocharger between the two securing bolts and the two prick-punch marks on the face of the turbine-inlet flange. Alternately tighten each bolt in increments up to the final torque of 120-130 lb.-ft. (163-176 N-m).
 - (4) Check the fit of the manifold to the turbocharger. The assembled manifold flange must be square with the face of the turbocharger within 0.020 in. (0,5 mm). For example, if the manifold flange touches the

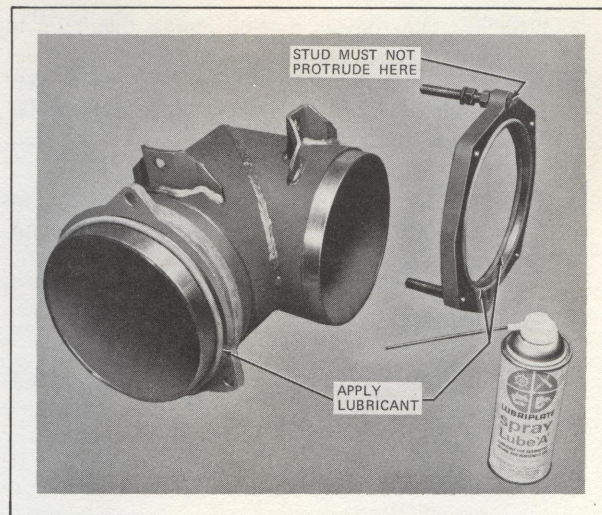


FIG. IX-110. ELBOW PARTIALLY PREASSEMBLED.

face of the turbocharger at one point, a 0.020-in. (0,5-mm) feeler gage shall not enter the joint face anywhere around the circumference.

- b. For single-pipe manifold, Fig. IX-105:
 - (1) Assemble the four lower bolts and washers which secure the turbine inlet flange to the turbine casing. Torque bolts to 120-130 lb.-ft. (163-176 N-m). Lockwire bolt pairs.
 - (2) Make sure all manifold turbocharger bolt threads are clean. If necessary, wire-brush all bolt threads and retap all threaded holes. Apply high-temperature anti-seize thread compound, Part 147X1640, to all threads of bolts and tapped holes and to the washer face of bolt heads.
 - (3) With a new gasket installed in the groove in the turbine inlet flange, assemble the lower clamp ring half and secure with bolts and new lockwashers finger-tight. The joint line of the clamp ring should be near horizontal.
 - (4) Assemble the top clamp ring half and secure with bolts and new lockwashers. After equalizing the gaps at the joint line, alternately tighten all bolts up to the final torque of 70-75 lb.-ft. (95-102 N-m).
14. Using new gaskets, assemble the two compression couplings to the water discharge header, Fig. IX-105.

15. Assemble the intercooler support bar, Fig. IX-105.
16. Install the stack and secure with bolts and lockwashers. Torque bolts to 55-60 lb.-ft. (75-81 N-m).
17. Connect the crankcase breather pipe to the crankcase breather and to the stack. Assemble and connect the four aspirator hoses, Fig. IX-106.
18. Reassemble the hatch over the turbocharger.
19. Fill the cooling-water system with properly treated water.

Operational Checks

After the turbocharger work has been performed and the engine is running, listen near the turbocharger and near the exhaust stack for unusual noises, such as parts rubbing.

If possible, load the engine and observe that turbocharger is performing its function. This will be evident by an indication of pressure on the turbocharger air pressure gage.

Check the installed turbocharger for water, oil, air and exhaust leaks and correct if found.

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